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EDITORIAL.

The Year's Progress.

With the commencement of a new year, we take the opportunity of reviewing progress during 1913, and of drawing the attention of our readers to one or two points of special interest.

One of the most important events of the year has been the appointment by the Home Secretary of a Departmental Committee to inquire into the subject of industrial lighting. In the course of visits to various parts of the country the writer has been struck by the unanimity of opinion among manufacturers as to the utility of these investigations. There is a general conviction that an inquiry which may suggest means of reducing the waste of human life and labour is one of national importance, and ought to be encouraged.

A feature of the recent work of the Illuminating Engineering Society has been its co-operation with other bodies. It was foreseen by Professor Thompson in his Inaugural Address in 1909 that one of the most important

sections of its work would be the bringing together of other institutions in order to attack problems of mutual interest. During the past year the Society has several times thrown open its meetings to other bodies interested in the subject of the evening. On the occasion of Mr. Liberty's lecture on the Centenary of Gas Supply a general invitation was issued to members of the Institution of Gas Engineers to be present. Similarly, when Mr. Trotter read his paper on the proposed Standard Specification for Street Lighting, the various institutions represented on the Joint Committee were asked to send delegates; and last month, when Mr. Waldram read his paper on "Some Problems in Daylight Illumination," an invitation was likewise issued to the Royal Institute of British Architects, the Society of Architects, the Surveyors' Institution and the Association of Medical Officers in Schools.

The formation of the Joint Committee on the Standard Specification for Street Lighting was in itself a great step. This Committee is still continuing its labours. Meantime, the Joint Committees on School and Library Lighting have issued interim reports on the artificial lighting of schools and libraries, and the attention these reports have received shows that general recommendations of this kind are most welcome.

Another very important event of the past year is the creation of the International Commission on Illumination and the formation, under its auspices, of National Illumination Committees. As will be seen from the notice appearing in the present number a very representative national committee has now been formed in this country. This body will doubtless be eminently fitted to give effect to conclusions arising out of discussions of the Illuminating Engineering Society, and will act as a channel by means of which such conclusions may be brought to the notice of the International Commission on Illumination.

During the past year there has again been a very considerable amount of notice given to illumination in the daily and technical press, and we take this opportunity of acknowledging the assistance thus given to the movement. One other event of the year—the National Gas Exhibition—deserves special mention, and the conferences arranged at the Exhibition were undoubtedly a most effective means of bringing illumination before the notice of the general public.

Daylight Problems.

In this number we publish the valuable paper read by Mr. P. J. Waldram at the last meeting of the Illuminating Engineering Society, together with a series of communications received from authorities in foreign countries on the above subject. We feel sure that those who read this paper will recognise the amount of work Mr. Waldram has put into the paper, on a subject with which he has been so much identified. A word of thanks is also due to Dr. Kerr and Dr. Nash, who in the appendices have collected together a variety of information not readily available to the English reader

and to the valued correspondents in different parts of the world who have so readily put their experience at our service.

It was at once recognised that a single evening would be insufficient for the discussion of a paper covering such a wide ground. It has, therefore, been decided to continue the discussion on January 15th. At the last meeting there was only time for the representatives of the Royal Institute of British Architects and the Association of Medical Officers in Schools to say a few words, and there will doubtless be many others with inquiries to make at the next meeting. The problem is one of great interest to the architect. Mr. F. R. Farrow, F.R.I.B.A., made a cordial reference to the aims of the Society and expressed the interest of the Royal Institute in the work so far accomplished. We feel sure that those connected with the more purely engineering aspects of illumination are likewise impressed with the great help the architectural profession could render to the cause of good illumination.

We prefer not to deal now with the many interesting and debatable points raised in Mr. Waldram's paper. There will be another opportunity when the discussion has been resumed. It is most instructive to compare the views of the foreign contributors and to see how in some respects they agree, while in others no definite conclusion as yet seems possible.

We have, once more, a contribution from Prof. L. Weber of Kiel, who, in connection with Prof. Cohn of Breslau, was responsible for so much pioneering work on the natural lighting of schools. We need only mention the exhaustive series of tests Prof. Weber has carried out for several years, showing the average variation of daylight throughout the day and at various times during the year. A similar series of experiments, carried out in this country, would be of immense value. It could hardly be expected that the conditions in England, and particularly in a large city like London, would yield precisely similar results, and at present we have very little information of this kind. Yet until such tests have been made it is difficult to approach the problem of providing daylight for buildings with any precision. This is a matter which the Meteorological Office might quite well take up. At present such work is rather laborious, as we have as yet no trustworthy light-recording instruments similar to those used for temperature, moisture, or CO_2. But no doubt such instruments may be designed eventually. Another line of research Prof. Weber has taken up, the specification of access of daylight in terms of the ratio between the indoor illumination and the unrestricted illumination outdoors, is also one which Mr. Waldram has independently followed. It is interesting to observe that Prof. Weber's suggestion that a schoolroom might be considered moderately well-lighted if it received 0·5 per cent. of the unrestricted outdoor illumination, is not far removed from the results so far obtained in this country.

These experiments have an intimate bearing on ancient light cases. Would it not be possible to come to some agreement as to the amount of daylight that is physiologically and practically necessary in a schoolroom,

office, or factory, at a certain time of day? If some such criterion could be established, there would be a good prospect of determining by photometric means when, as a result of some outside obstruction, the desired minimum was likely to be affected. At present the difficulty in all such cases is to determine when any material damage has been done by the partial obstruction of daylight. Similarly in schoolrooms and factories it would be most valuable if we could agree on the minimum illumination below which artificial light becomes essential.

It is common knowledge that the period when daylight is waning is apt to be a troublesome one in the workshop, and that some time is needed for workers to become accustomed to the change from natural to artificial lighting conditions. A closer study of daylight might enable us to devise better means of tiding over the transition period and reducing the amount of spoiled work that is apt to occur at this time of day.

There are also many buildings in which expensive structural alterations or special devices are introduced with a view to improving the access of daylight. In many such cases the improvement is too slight to be really worth while and it would be better if it were agreed from the beginning that artificial illumination would be necessary. Possibly definite agreement as to the conditions of illumination which constituted the permissible minimum would be useful in such cases.

It may also be remarked that there is a close affinity between daylight problems and ventilation. Very frequently it becomes necessary to strike a compromise between the window space desirable for admission of daylight and the amount of glass that can safely be allowed without making the cost of heating such a room excessive. Again, there may be cases in which skylights are very desirable from the lighting standpoint and yet may cause upward currents of air such as considerably affect the ventilation of the room. Evidently anyone who wishes to be an expert on daylight problems should have some knowledge of the science of heating and ventilation as well.

In conclusion, we may add that the study of daylight is of direct interest even to engineers, who are almost entirely connected with artificial illumination. Our ideas of what is necessary by night are to a great extent influenced by our impressions during the day. If people come to realise that the abundant access of daylight into schools, offices, and factories is important from the hygienic standpoint they will not be satisfied unless the artificial illumination is also good. Any improvement in the standard of daylight illumination should bring about a corresponding advance in the standard of artificial light. To the Illuminating Engineering Society, therefore, the whole subject of daylight illumination is one of considerable importance. We shall look forward with interest to the resumed discussion on January 15th.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(A REPORT PRESENTED AT THE SEVENTH ANNUAL CONVENTION OF THE AMERICAN ILLUMINATING ENGINEERING SOCIETY, PITTSBURGH, PA. (U.S.A.), SEPTEMBER 22-26TH, 1913.)

(*Continued from p.* 599, *Vol. VI.*)

Gas Lamps and Appurtenances.

A large number of new types of gas lighting units have made their appearance in both hemispheres. Some of them have been designed with a view to more universal adaptability, such as a burner with a curbed bunsen which may be turned either up or down, and is therefore applicable to either upright or inverted burners;[31] some with a view to ease of maintenance, such as one in which the main feature is the possibility of lifting from the fixture, without the use of pliers;[32] and some with a view to increased efficiency, such as one in which the mixture of gas and air issue at high velocity;[33] resulting in an efficiency claimed to be double that of the standard type; also another lamp with an upright bunsen and an inverted mantle.[34] Low-pressure high-efficiency lamps, particularly for out-door use and giving 1,500 candle-power and with an efficiency of nearly 40 candles per foot have been introduced abroad, but have not yet appeared in this country.

What is probably the most important development in gas lighting during the past year is the introduction of a high power single-mantle inverted lamp filling a place between the old small unit and the multiple mantle lamp. The lamp gives from 180 to 225 mean spherical candles according to the gas used and the pressure, and thus occupies a space hitherto unfilled. A valuable feature of this lamp is the fact that, because of the single mantle the light is concentrated and reflectors and glassware may be designed with much greater precision than with the multiple mantle lamp.[35]

Hitherto one of the difficulties in connection with the use of high-pressure lamps was the heat developed which limited the kinds of glassware available and also necessitated a globe of very great size. In a modification of one of the high-pressure inverted lamps now in wide use, particularly in England, a small silica cup about 5 inches high, and therefore but little larger than the mantle itself, has been substituted for the globe hitherto

[31] *Journal of Gas Lighting*, October 1st, 1912.
[32] *Journal of Gas Lighting*, September 24th, 1912.
[33] *Le Genie Civil*. November 23rd, 1912.
[34] *Journal of Gas Lighting*, September 14th, 1912.
[35] *Lighting Journal*, July, 1913.

used. This cup totally excludes the secondary air supply, all air for combustion being admitted as primary air. The lamp, moreover, is greatly reduced in size and the reflector is omitted. It is claimed that after allowing for the absorption of light by the silica cup a 10 per cent. increase in efficiency is obtained. These cups are made for lamps of from 60 to 1,500 candle-power. They are very durable and will not break if the mantle gives way and the flame strikes them.[36, 37]

A new high-pressure lamp has also been developed in the United States, designed particularly for street lighting, and working under a pressure of 55 inches of water or 2 pounds per square inch. These lamps are at present made in two sizes—500 and 1,100 candle-power respectively, and have an efficiency of over 50 candles per foot of gas per hour. The mantles are of artificial silk and have a life of over 400 hours with practically no depreciation in candle-power.[38] High-pressure lighting, however, has not been developed in the United States to the same extent as abroad.

The artificial silk mantle is steadily coming into use, its durability, long life and strength being its recommendations. By a recent improvement in this type of mantle, it can be burned directly on the burner, so that all burning off, collodionizing, etc., becomes unnecessary.[39]

A most interesting and valuable investigation was made to determine the cause of the falling off in candle-power of the incandescent mantle. Microscopical examination showed that when new the ash seemed to be made up of very small particles, making an opaque and light-giving structure. As the mantle was heated, these particles gradually fused together to form larger particles and, by degrees a large transparent mass, which, by the laws of physics, is comparatively without light-giving properties.[40]

Other experiments were made to apportion to each part of the lamp its share of the deterioration. Under favourable conditions, the deterioration in 1,000 hours' continuous burning was :—

	Per cent.
For the mantle alone ..	2½
For the burner alone ..	2½
For the glassware alone ..	10
Total deterioration ..	15

of which, by proper maintenance, 12½ per cent. could have been eliminated.[41]

Automatic gas ignition is having a steady growth. Pilot lights are increasing in number, while the jump-spark and filament igniters are gradually coming into use. Distance control by means of electrically operated gas cocks and also pneumatic control in connection with pilot and jump-spark ignition are being extensively employed, particularly in the past year. It should be noted here that pilot lights have been improved by adopting the bunsen principle and by better protection, so that the danger of extinction is greatly reduced. Self kindling mantles are also receiving attention, and one improvement recently made in this type of mantle was to mix ammonium chloride with rhodium chloride. The metallic rhodium deposited is of a silver grey and comes to full intensity without presenting a dark streak down the mantle. It has since been found that lithium chloride is cheaper and works better.[42]

The pyrophoric alloys are also in process of development, and are now on the market. A new composition of the alloy has been found which, instead of giving a shower of sparks, produces a long flame, thus rendering the friction wheel unnecessary. This alloy is air proof, and does not disintegrate like the old cerium alloy.[43]

Acetylene.

The use of acetylene is increasing for isolated buildings and for distribution from a central plant in very small towns. A large number of burners are available to suit varying needs, but as yet no incandescent burner has been devised for use with acetylene that is thoroughly satisfactory. An enormous field for acetylene

[36] *Journal of Gas Lighting*, February 18th, 1913.
[37] *Journal of Gas Lighting*, February 25th, 1913.
[38] *American Gas Light Journal*, December 30th, 912.
[39] *Gas World*, February 1st, 1913.
[40] *Lighting Journal*, April, 1913.
[41] TRANSACTIONS Illuminating Engineering Society, December, 1912.
[42] *Gas World*, February 15th, 1913.
[43] *Journal of Gas Lighting*, September 17th, 1912.

has been developed in lights for automobiles, where acetylene dissolved in acetone is dividing honours with the tungsten lamp. It is also stated that acetylene mixed with oxygen and used on a special disk of ceria gives a light almost equal to the electric arc and will shortly be put to use with the cinematograph.[44]

Sundry Systems.

Air gas systems and systems employing kerosene under pressure for use in connection with incandescent mantles are making considerable progress in the rural districts and other places not reached by city gas and electric plants. The former system, however, has had a setback in the increased price of gasoline and the difficulty in obtaining the high grade necessary. A new modification of the latter system consists of a gas arc lamp connected with the fuel tank by a fine flexible bronze tube. Laboratory tests showing 1,220 candle-power are claimed for this lamp.[45]

A new method of utilising natural gas has recently been brought out, but is still in an experimental stage. The plan is to pump the nearly exhausted wells and treat the gas in such a way as to produce a volatile liquid which, on release of pressure would evaporate into a utilisable gas.

Cold Light.

The startling announcement has been made that the long looked for secret of obtaining a cold light has been discovered in France, it being understood that the term "cold" is purely relative. A rotating wheel carrying a number of lamps at the circumference is arranged so that an electrical contact lights each lamp in succession. The result is a series of instantaneous flashes as each lamp passes the contact point, retinal persistence giving the effect of a steady light With this apparatus, the inventor claims to be able to run the lamps at a voltage of from two to four times the normal, and to obtain an efficiency thereby of 0.2 watt per candle, 2 watts per candle being normal.[46] In this connection, it may be said that the idea of supplying lamps with intermittent current is not new. Some fifteen years ago an inventor placed in the lamp circuit a commutator by which the current was interrupted a number of times a second, but nothing ever came of the plan. A test of the present system is on record from which we learn that the results are what might be expected from overrunning the voltage; the life of the lamps was reduced from one thousand hours to four hours.[47]

Luminous Animals.

The firefly is still the subject of research among scientists.[48] It is pretty well known that certain animals and insects have the power to produce by means of chemical reactions a form of radiant energy lying practically within the limits of the visible spectrum, but the nature of these reactions is not yet known. One investigator, indeed, separated out two substances called by him eluciferase and luciferine respectively which, when mixed and moistened, became luminous.[49] The nature of these substances is, however, a matter of doubt. A study has been made of the intrinsic brilliancy of the glowworm or larva of the firefly, which gave as a result 0.0046 candle per square centimeter. From this it was calculated that the luminous material of the glowworm, could it be reproduced, would not only be of high luminous efficiency but would also be a happy mean in intrinsic brightness, far lower than the artificial light sources with which we now try our eyes, yet high enough to permit its use without pre-empting more wall space than we now give to windows.[50]

(*To be continued.*)

[44] *Gas World*, January 18th, 1913.
[45] *Iron Age*, January 23rd, 1913.
[46] *Scientific American*, May 31st, 1913.
[47] *Journal of Gas Lighting*, May 13th, 1913.
[48] *Lighting Journal*, January, 1913.
[49] Philadelphia *Public Ledger*, April 6th, 1913.
[50] *Lighting Journal*, February, 1913.

TWO NOVEL INDIRECT LIGHTING BANK INSTALLATIONS.

THE two illustrations on the opposite page show a highly novel and interesting method of indirect lighting which has been introduced into several banks in Chicago. Fig. 1 shows a view of the Swedish-American Bank, the illumination of which is accomplished by special reflectors using 60-watt lamps which are fitted into each of the eight boxes or troughs along the bank rail over the tellers' desks. For the main lighting there are thus no suspended fittings. It is stated that this absence of pendant fittings preserves perspective in a remarkable manner and tends to give the room a high, spacious appearance. In addition, the lights being comparatively distant from the ceiling, the illumination of the upper part of the room is exceedingly uniform.

This main bank room is 50 ft. long, 32 ft. wide, and 26 ft. high and the reflectors contained in the casings for the bank room are 9 ft. above the floor. There are also two skylights in the ceiling which illuminate the room during the day. These are also utilised for artificial lighting after dark, eight reflectors using 100-watt lamps being mounted above the glass.

These photographs were taken entirely by the artificial light. The hands of the clock in Fig. 1 show that the exposure was just about five minutes—a fairly low value for a photograph of this kind.

There are also four fittings carrying 150-watt lamps for the vestibule entrance, but these, being at the opposite end of the bank, are not shown in the photograph. These, however, add to the general effect.

The second photograph shows a portion of the bank of the Union Trust Co. (also in Chicago), which is lighted on a similar plan. In this case the comparatively low ceiling would have made it difficult to use pendant fixtures so that the use of lamps in boxes for the bank room is very convenient. The room shown is 74 ft. long, 38 ft. wide, and 12 ft. high, and the troughs above the tellers' desks contain 180 small reflectors, each equipped with one 25-watt lamp. The distance from the top of the reflector to the ceiling is $4\frac{1}{2}$ ft. The consumption of electricity amounts to about 1·6 watts per sq. ft. and the average illumination is given as 4 ft.-candles. Several similar installations have been made in banks in the United States at Evansville (Indiana) and elsewhere, and the method seems to be proving very acceptable.

For the photographs and particulars embodied in this article we are indebted to the courtesy of Mr. C. M. Bunn, Engineer-in-Charge to the National X-Ray Reflector Co. (Chicago).

LIGHTING IN PARIS.

RECENT statistics, gathered by M. Lauriol, Chief Engineer of the lighting service of Paris, show that the lighting powers of the apparatus used for public purposes amount to about 7,000,000 candles. The quantity of gas employed for public lighting exceeds 91,600 cubic metres—or 3,234,000 cubic feet. For private service, the consumption for lighting, heating and power amounts to 1,140,000 cubic metres (4,025,000 cubic feet). The measure of electricity used in 24 hours is 13,000 kilowatts for public lighting and 154,000 kilowatts for private purposes.

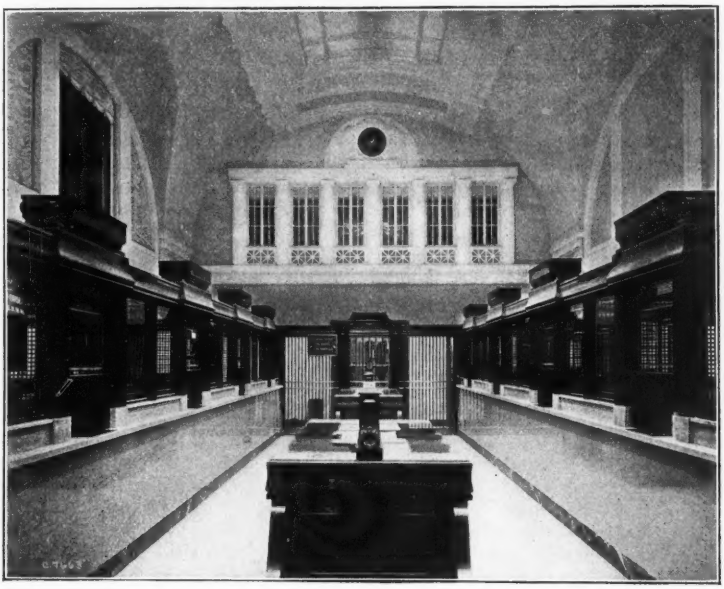


FIG. 1.—A view of the Swedish-American Bank, Chicago.

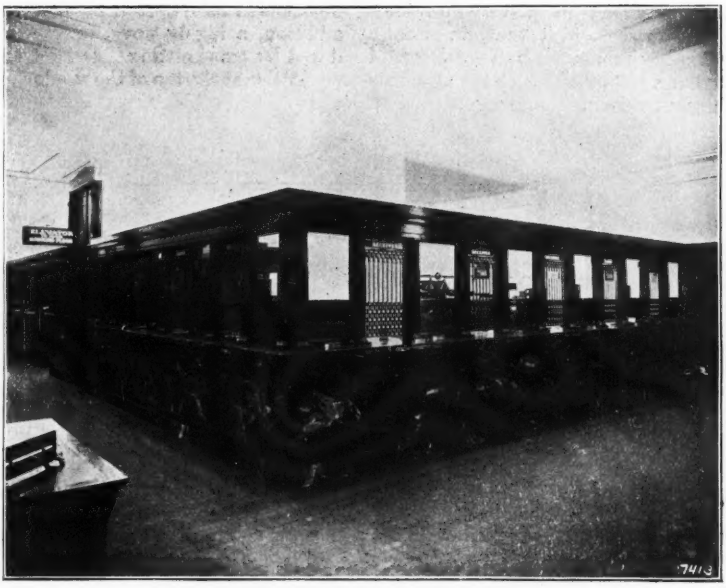


FIG. 2.—A view of the Union Trust Co.'s Bank, Chicago.

Two photographs of Interesting Indirect Installations in the Banks in Chicago. The illumination derived from lamps concealed in trough reflectors mounted above the bank rail.

(Photos. taken entirely by artificial light.)

ARTISTIC LIGHTING OF SHOP WINDOWS.

GOOD examples of shop window lighting are always interesting. It will be recalled that last year we reproduced some illustrations of the effects at Harrod's Stores in London. We have now received from the Public Service Electric Co., of New Jersey, U.S.A., some more good examples of novel lighting effects in the United States. Two of these are reproduced on the opposite page.

The first illustration shows a window in the famous Wanamaker Stores. John Wanamaker in the Philadelphia Press, April 5th, 1913, remarked that " the art of present-day storekeeping is not the restoration of a lost art, but the invention of a new art far superior to the best customs of fifty years ago." The same might be said about shop window lighting. In Fig 1. the lighting comes entirely from overhead, and the background of the window has been specially designed to form part of the whole display. This illustration shows in a very practical form the modern idea that an artistic show window should not be a catalogue of goods, but a *picture* by which the attention of passers-by is involuntarily attracted. Some experiments were carried out by the Public Service Electric Co. with a view to demonstrating the increased attention secured by a well lighted window. In one instance it was observed that a certain show window attracted the attention of 12 per cent. of the passers-by. The lighting equipment was then entirely altered, the illumination being used in a decorative way as part of the display. A count then showed that the attention of no less than 72 per cent. of the passers-by was attracted. Thus, the attractive power of the window had been increased no less than 500 per cent., and it is stated that the difference in the cost of current was only 2 cents. (about 1d. per hour).

Fig. 2 shows a view of this very window. It will be observed that the illuminated lanterns and parasols, besides giving a certain amount of light to the surroundings, in themselves constitute decorative objects and form part of the picture. In addition, a highly novel effect was produced by transmitting blue light through the lattice at the top of the window, giving the effect of a blue sky.

LIGHTING OF ROADS AND VEHICLES.

A CORRESPONDENT sends us the following quotation from a newspaper in Calcutta. It is evident that the illuminating engineering standpoint in street lighting is making headway in distant lands.

The report submitted to the Road Congress on this subject seems to us to offer the solution of a very real difficulty in lighting. For road lighting the suggestion is made that lamps should be higher and shaded with ground glass, and for vehicles it is suggested also that lamps should be placed higher. A ground glass shade diffuses light better than a plain glass shade and, we think, lights the atmosphere better; and although it obstructs a certain amount of light we think its effect in the street will be really to produce more general illumination, the effect of which will be enhanced by hanging the lamps somewhat higher than is usual now. A low-placed light on a vehicle most certainly has the effect of exaggerating ridges and hollows on the road, besides bewildering the comer from an opposite direction. Placed high it would both light the road better and distract the drivers of other vehicles less. In their case we also think ground glass shades would be an improvement. These may appear small matters, but we think if the opinions given were proved and followed an enormous benefit would be conferred on the public.—*Indian Engineering*, September 13th, 1913.

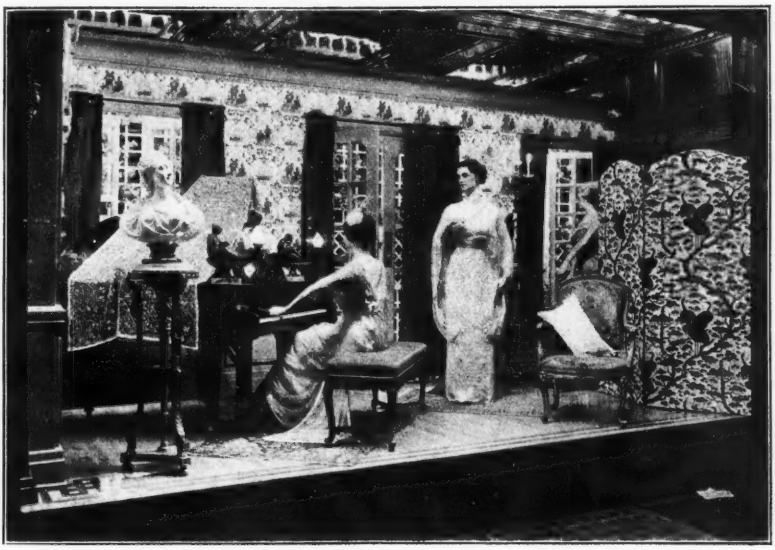


FIG. 1.—A view of a show window in the Wanamaker Store, lighted from above.

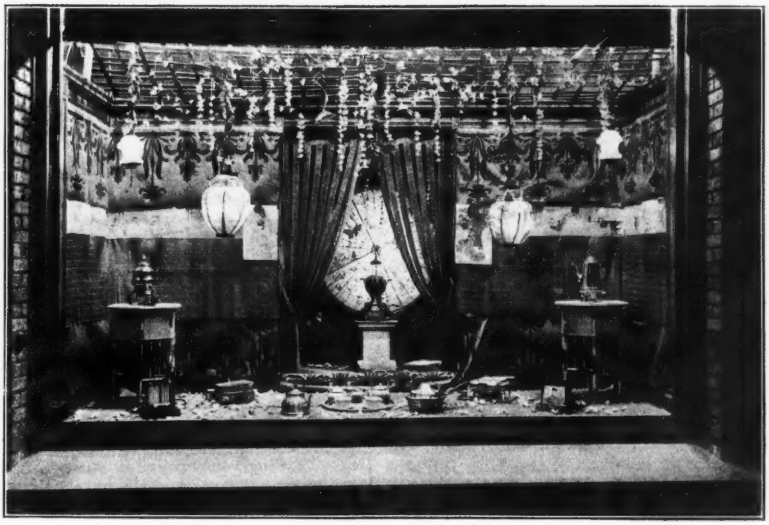


FIG. 2.—Another window in which lighted lanterns, illuminated parasols, etc., form part of the decorative scheme.

A NEW METHOD OF SEALING ELECTRODES IN THE QUARTZ TUBE MERCURY VAPOUR LAMP.

E. WEINTRAUB* describes a new method of sealing electrodes into quartz tube lamps. Hitherto, as is well known, it has been necessary to use tungsten for this kind of glass, the metal being accurately ground in, and not sealed. The difficulty of sealing in the metal into quartz is due to the high temperature at which quartz melts and to the difference in coefficient expansion of quartz (0·5 by 10^{-6}) and that of platinum (9 by 10^{-6}). Now the coefficient expansion of tungsten lies between this limit, being about 3·5 by 10^{-6}.

A glass with a high melting point and a coefficient of expansion near this value was therefore sought. Eventually, a type of boro-silicate glass was found which answered perfectly and adhered closely to the tungsten metal, making a vacuum-tight seal—indeed, a seal which is in many respects even superior to the ordinary seal between platinum and lead glass. This improvement will make possible a higher temperature in the lamp without leakage, and it is hoped will improve the life of these lamps considerably.

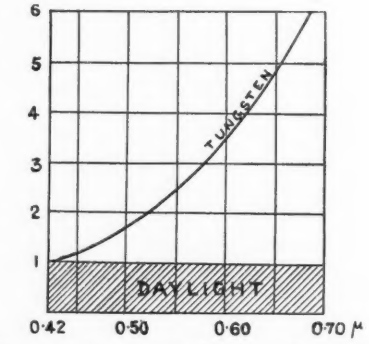
Another result of this improvement has been the use of a solid tungsten anode. The ordinary mercury lamps have both electrodes of mercury, and the use of a mercury anode has a number of disadvantages. The substitution of tungsten will remove the necessity for "balancing" the mercury vaporisation of the two electrodes, and the heat dissipating devices (metallic veins, &c.) are also no longer required. It is also expected that the simplification in design attained by the use of tungsten will be particularly convenient in connection with the lamp now made for the alternating currents.

* *Electric World*, May 10th, 1913.

THE NEW TUNGSTEN DAYLIGHT LAMP.

IN a recent number of the *Zeitschrift für Beleuchtungswesen* an account was given of the new Verico lamp recently developed in Berlin. The difference between daylight and artificial light of the light from a tungsten lamp is shown in the accompanying diagram. What is needed is a screen with a progressively increasing absorption as we approach the red, so as to cut out the excess of light at this end of the spectrum and make it the same as daylight.

In the Verico lamp this is done by means of a special colouring in which the absorption is restricted to the region of the spectrum between 0·48μ and 0·62μ. While this does not give a light exactly equivalent to daylight, it is, for many practical purposes, considered to be sufficiently near. The result of this approximation is that a comparatively high efficiency is available, the lamps consuming only about 1·4 watts per candle.



Curve showing comparative intensity throughout the spectrum of daylight and the tungsten lamp.

TRANSACTIONS

OF

The Illuminating Engineering Society

(FOUNDED IN LONDON, 1909.)

(The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.)

SOME PROBLEMS IN DAYLIGHT ILLUMINATION

WITH SPECIAL REFERENCE TO SCHOOL LIGHTING.

[Proceeedings at a meeting of the Society held at the House of the Royal Society of Arts (London), on Tuesday, December 16th, 1913.]

A PAPER on the above subject was read by Mr. P. J. WALDRAM at a meeting of the Society on December 16th, the chair being taken by Dr. James Kerr.

The minutes of the last meeting having been taken as read, the Chairman called upon the Hon. Secretary to read out the names of new members in the usual way (see p. 14).

THE CHAIRMAN then called upon MR. P. J. WALDRAM to read his paper entitled "Some Problems in Daylight Illumination," which is reproduced *in extenso* on pp. 15—32, and subsequently himself gave a brief summary of research in foreign countries, which forms an appendix to Mr. Waldram's paper (p. 27).

THE CHAIRMAN next asked the Hon. Secretary to read letters from Sir Geo. Newman, Sir Henry Tanner, F.R.I.B.A., Mr. W. Woodward, Mr. Chatfield Clark, Mr. Digby Solomon, A.R.I.B.A., and others regretting their inability to be present.

MR. J. S. Dow was then called upon to present a summary of the replies received from foreign correspondents to a series of queries issued by the sub-committee of the Society engaged in studying this subject (see p. 33).

MR. F. R. FARROW, F.R.I.B.A., representing the Royal Institute of British Architects, then said a few words expressing his appreciation of the paper, and of the work which the Illuminating Engineering Society was doing.

DR. E. H. NASH, representing the Medical Officers of Schools Association, also joined in the discussion, and showed a number of slides illustrating methods of school planning in this and other countries.

THE CHAIRMAN, in closing the discussion, remarked that the ground covered in the paper was too wide to be dealt with that evening, and it has therefore been resolved to continue the discussion at the next meeting of the Society on Thursday, January 15th, 1914, when he hoped many of the audience would again be present.

OFFICIAL ANNOUNCEMENT OF NEXT MEETING.

(To be held in the House of the Royal Society of Arts, 18, John Street, Adelphi, London, at 8 p.m. on Thursday, Jan. 15th, 1914.)

At this Meeting the discussion on the paper by Mr. P. J. Waldram, F.S.I., entitled: "Some Problems in Daylight Illumination, with special reference to School Planning," will be resumed.

Copies of the paper can be had on application to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.).

NEW MEMBERS OF THE SOCIETY.

THE names of applicants for membership read out at the previous meeting on Nov. 18th* were formally announced at the last meeting, on Dec. 16th, and these gentlemen declared members of the Illuminating Engineering Society.

In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were also read out by the Hon. Secretary at the last Meeting:—

Clewell, C. E.	Lighting Engineer, 188, Dwight Street, NEW HAVEN, Conn., U.S.A. (1)
Farthing, T. H.	Deputy Manager, The General Electric Co., Ltd., Victoria Bridge, MANCHESTER. (1)
Greenly, A. J.	Director of *The Lighting Journal*, 1, Eccleston Road, Ealing, LONDON, W. (1)
Howard, H. C.	Elec. Engineer, Messrs. Horne Bros., 388, Strand, LONDON. (1)
Helps, W. D.	Managing Director of Messrs. Jas. Milne & Sons, 34, Wellington Street, LEEDS. (1)
Lackie, W. W.	Elec. Engineer to the City of Glasgow, 75, Waterloo Street, Glasgow. (1)
Palmer, H. C.	Publicity Dept., General Electric Co., Ltd., 67, Queen Victoria Street, LONDON, E.C. (1)
Roberts, A. L.	Architect to the Southampton Education Committee, The Castle, WINCHESTER. (1)
Robinson, A. W.	Ed. of *The Lighting Journal*, Ashside, Hampton Wick, LONDON. (1)
Sinclair, F. B.	Elec. Engineer, Manager Elec. Street Lighting Apparatus Co., 11, Victoria Street, LONDON, S.W. (1)
Walters, A. E.	Lighting Inspector on the N.S. Wales Govt. Railways, Shiplake, Parramatta Road, CONCORD, New South Wales. (1)
Walton, W. H.	Elec. Engineer, Messrs. Pinching & Walton, 52, Cannon Street, LONDON, E.C. (1)

* *Illum. Eng. Lond.*, Dec., 1913, pp. 609—611.

NATIONAL ILLUMINATION COMMITTEE OF GREAT BRITAIN.

A PROVISIONAL committee, formed of representatives of the Illuminating Engineering Society, the Institution of Electrical Engineers, the Institution of Gas Engineers, and the National Physical Laboratory, held a meeting on 29th November last, at which arrangements were made for the formation of a National Illumination Committee, to be constituted according to the Statutes of the International Illumination Commission with the primary object of affiliating Great Britain to that Commission.

The provisional committee recommended that the National Committee should consist of five representatives of each of the three technical societies and two representatives of the National Physical Laboratory. This recommendation has been adopted, and the following have been nominated as members of the Committee: By the Illuminating Engineering Society: Mr. Leon Gaster, Mr. F. W. Goodenough, Prof. Silvanus P. Thompson, and Mr. A. P. Trotter (this Society has not yet nominated its fifth representative). By the Institution of Electrical Engineers: Mr. F. Bailey, Mr. W. Duddell, Mr. K. Edgcumbe, Mr. Haydn Harrison and Prof. J. T. Morris. By the Institution of Gas Engineers: Mr. E. Allen, Mr. J. Bond, Mr. W. J. A. Butterfield, Dr. H. G. Colman, and Mr. H. Watson. By the National Physical Laboratory: Dr. R. T. Glazebrook, C.B., and Mr. C. C. Paterson.

The first meeting of this National Committee took place on the 2nd inst., when the following were chosen as officers:—

Chairman, Mr. E. Allen, of Liverpool; Vice-Chairmen, Mr. W. Duddell and Mr. A. P. Trotter, both of London, and Honorary Secretary and Treasurer, Mr. W. J. A. Butterfield, of London. Great Britain is entitled to two delegates on the Executive Committee of the International Illumination Commission, and Dr. H. G. Colman and Mr. W. Duddell were accordingly appointed by the Committee as the delegates from this country.

SOME PROBLEMS IN DAYLIGHT ILLUMINATION.

WITH SPECIAL REFERENCE TO SCHOOL PLANNING.

By PERCY J. WALDRAM, F.S.I

Paper read at the Meeting of Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m. on Tuesday, December 16th, 1913.

IT would at first sight appear to be improbable at this stage of scientific investigation that anything new or interesting could be said with regard to such a subject as daylight illumination, which is so vitally necessary to our existence that it is the object of the daily, hourly observation of every normal human being. Still less would one expect it to present difficult problems materially affecting large momentary considerations, or to find many of those problems habitually solved, by those who are professionally engaged to do so, only by the most random guesswork, rendered still more uncertain by ignorance of facts which might be ascertained by ordinary observation.

Yet such is actually the case; and this paper is presented with no little diffidence, not because the subject is barren of interest, but rather because the writer appreciates the difficulty of adequately presenting its vast potentialities as a field of research. Neither is that diffidence caused by the simplicity of the problems involved but rather because the writer is conscious of the difficulty of doing justice to their complexity.

Nor is there reason to entertain any fear of wasting your time over a subject which affects no monetary interests and therefore concerns the scientist rather than the engineer. On the contrary, the correct solutions of daylight problems affect such large sums, both of capital expenditure on buildings and of annual expenditure on heating, rental value, dead rent of light wells, &c., that one cannot help feeling considerable apprehension in even indicating what appear to be suitable lines of investigation.

The illumination of buildings by natural light, as obtained by forming openings in the walls and ceilings of rooms, is an operation which so materially influences the structure and the subsequent utility and value of all buildings, to say nothing of the architectural and other amenities, that one is rather staggered to find that practically no rules exist which determine what width, height and arrangement of glass area will afford adequate illumination for any given size of room. Still more strange is it to find no recognised criterion in existence as to what is adequate natural illumination for any given purpose, such for instance as a school, a library, a dwelling house, an office, a retail shop or a workshop.

By means of vertical windows we admit to our rooms a small (an extremely small) proportion of the illumination enjoyed outdoors, but what that proportion should be for any specific purpose has yet to be defined. When we come to consider the matter we find that the daylight source varies from month to month and from hour to hour on normal days by several hundreds per cent., whilst on many days it will vary by

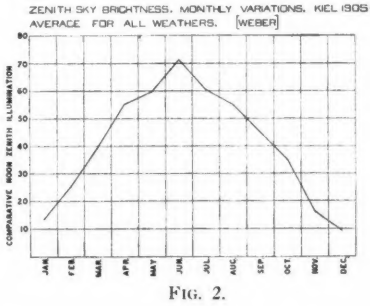


FIG. 2.

50 per cent. to 100 per cent. in the course of a few minutes. Figs. 1 to 3 show the variation on typical days given by

different authorities, and Figs. 4 to 6 show the difference between a clear still afternoon in November in London, a windy day, showery with bright intervals, and a dull, wet day.

It will at once be seen that the extent of these variations in changeable weather is really far greater than is commonly supposed. This fact alone makes the measurement of the ratio of the outside light which is enjoyed by any room a difficult task even with accurate and handy measuring instruments—except on light, grey days, when the sky is of equal and approximately permanent brilliance for considerable periods of time. When in addition we consider the idiosyncrasies of the unaided human eye it will be seen that its estimates of natural illumination are liable to vary enormously without the estimator being even aware of his errors. Herein lies the explanation of the curious anomaly that in ancient light cases the most absolutely contradictory evidence may be given in perfect good faith by different experts of equal skill, whose integrity is above suspicion, and who may be quite capable of fairly appraising the effect of all other matters tending to modify the value of real estate, and of tracing such effects amongst the ramifications of underleases and subsidiary interests.

It is simply because experts trust to the impressions received by their unaided eyes; in ignorance of the fact that isolated impressions cannot be taken as even rough criteria of average conditions over long periods; and that the eye as a measuring instrument is so hopelessly inaccurate that to depend upon it for estimating natural illumination can only be compared with an attempt to locate the points of the compass by observing the direction and temperature of the wind.

Prof. Silvanus Thompson in the course of a paper read on 11th October last at a Congress of Educationists at the Gas Exhibition, stated :—

"At the best the human eye is a very bad photometer. Its automatic adjustment, which closes the pupil in the presence of a flood of light and opens it in twilight—a most valuable provision of nature—works against it as a measuring instrument. And Fechner's law of psycho-physiology concerning the numerical relation between a stimulus and its resultant sensation, shows, once and for all, the impossibility of setting up the eye as a judge of photometric values. The one and only thing that the eye can do in this regard—and it is the principle of every photometer—is to draw a judgment as to the equality or non-equality of the illuminations on two adjacent patches of space in the field of vision."

It is also necessary to appreciate some other little known peculiarities of the human eye. Although its measuring ability is so poor in the presence of artificial light, it is infinitely less capable of appreciating variations of daylight. After some experience we can, by exercising due care, estimate the amount of artificial illumination falling upon a white card with a matt surface to within perhaps one or two foot-candles, and excessive artificial illumination on such a source, say 10 to 15 foot-candles, causes us acute discomfort. But few people would be conscious of any material difference in illumination if they passed from an ordinary interior into the open, even though whilst doing so they kept their eyes fixed upon a white matt card or a piece of ordinary printed paper. Yet whilst inside the illumination might be considered of quite average and adequate strength, outside it would be—not ten or fifty per cent. stronger—but probably a thousand to two thousand times as strong. To our eyes it appears a little stronger, an impression which is, perhaps, subconsciously accentuated by the fact that we naturally expect it to be so; but a ratio of a thousand to two thousand to one seems absurd, until we try it with a photometer or attempt to photograph in the two positions with the same stop.

A thousand foot-candles of daylight or sunlight is less trying to our eyes than 10 foot-candles of artificial light. This is possibly due to the fact that we have only been accustomed to the use of the latter for say 150 years or so—a period which is extremely minute in comparison with the countless ages through which our eyes have developed under natural light.

Also, it may be noted that the supreme indifference of our eyes to huge variations

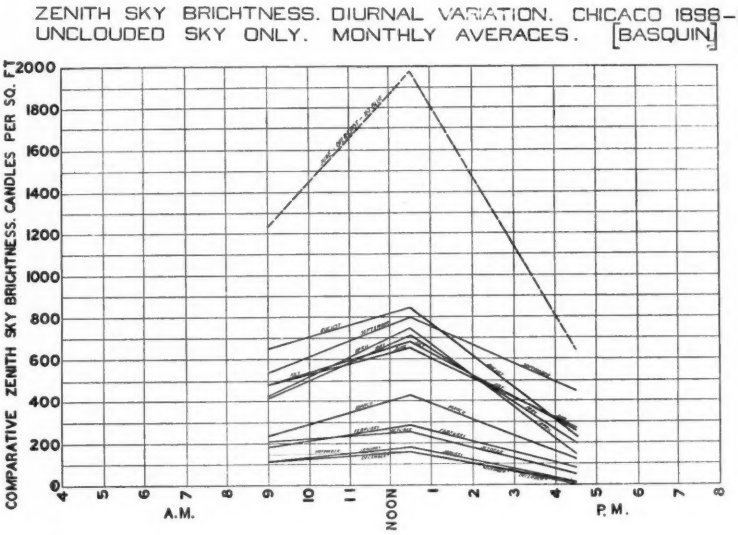

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FIG. 1.

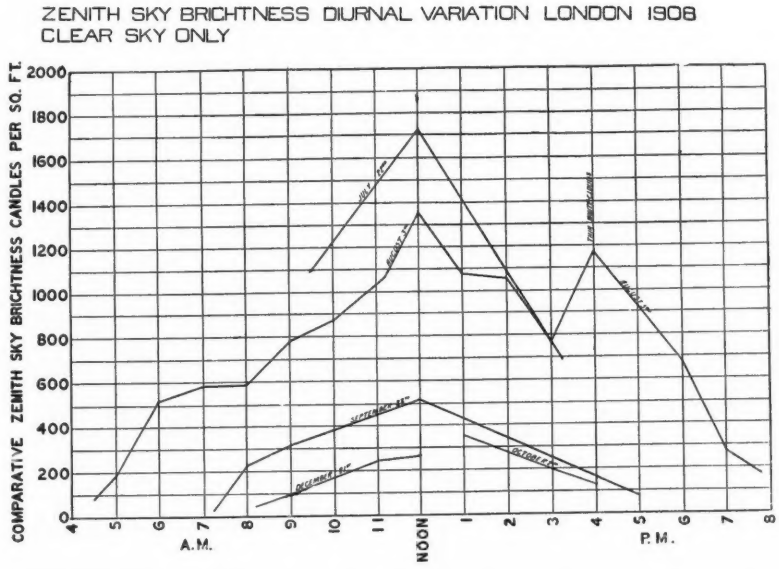
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FIG. 3.

of ample natural illumination is replaced at low intensities by a sensitiveness to variations which approximates to that supersensitiveness which obtains under artificial light, which so many people regard as its normal capacity for appreciating degrees of illumination. The reason of this is, possibly, also hereditary. For many thousands, possibly millions, of years, increases of low illumination must have heralded to our open-air ancestors the approach of dawn and were signals to be noted if the valuable hours of daylight were to be utilised. Similarly, variations of waning light indicated the approach of a storm or of nightfall, and only by noting carefully the intensity of such variations could the time available for reaching shelter be gauged.

When the due observation of these variations made all the difference between comfort and discomfort, or even between life and death, naturally the eye would have been trained to note them. Also in the dim twilight of forests an alert intensity of vision was called for which was unnecessary in the open; where the fact that the light varied by anything up to 800 per cent. to 1,000 per cent. between sunrise and noon and between noon and sunset had no special significance, because the difference between one day and another or even between different parts of the same day rendered it useless as a means of gauging the passing of time.

There are yet other counts in the indictment which one must draw up against the eye as a measuring instrument of daylight, which are no less important and are possibly capable of similar explanation.

When man had to trust mainly to his eyes and wits against the attacks of wild animals, anything which obstructed the view was obnoxious, and an unobstructed aspect was invaluable. Whether we are still so influenced or not, people will certainly often stand up in the middle of an empty room and judge of its daylight illumination for reading, writing and working by the view from the windows and their size, taking no note at all of the height of the window heads in relation to the depth of the room. There are also still architects who will compress a glass area of one-tenth of the floor space into low, broad windows and expect them to light a deep room.

The eyes of many people also are particularly susceptible to colour, and if the walls of a room be covered with a white paper with a light pink pattern, the eye, noting their cheerful lightness, will pronounce the room a light one whether it really be so or not. On the other hand if the walls be dull grey or brown, as in the Court Rooms of the Royal Courts of Justice, one is obsessed by their sombre gloom and will find it most difficult to avoid the conclusion that the Courts are dull and badly lit, even though by virtue of their high windows or lantern lights they may really enjoy a degree of illumination for reading and writing such as is received by very few ordinary rooms, and may be able to dispense with artificial light on a winter afternoon for a considerably longer period than would be possible in a room lit with windows of the ordinary height.

We must also make ample allowance for the fact that clear blue sky necessarily suggests the idea of unobscured sunlight, which gives the most intense degree of illumination which our eyes will stand; whilst on the other hand clouds indicate a material reduction of such light. But these are outdoor conditions, and as we have taken to living and working so much indoors, our intuitive impressions are apt to prove deceptive unless we recognise that blue sky gives us very little of that diffused light upon which all interiors must depend, when they are not receiving the sun's rays, direct or directly reflected. White or very light grey clouds in fact materially increase the illumination of interiors.

The very commonly held supposition that the contrary is the case is often bolstered up by the tests of the length of time required to darken photographic paper, which, however, is unduly sensitive to the rays of light from blue sky. This is unfortunate, because otherwise such photographic tests would have been valuable in many cases, instead of being as they are sometimes accurate, sometimes approximate, and sometimes wholly erroneous.

The only accurate practical method we have at present of measuring illumina-

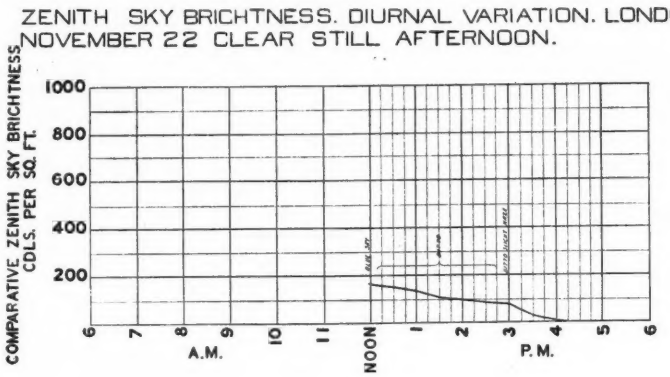

FIG. 4.

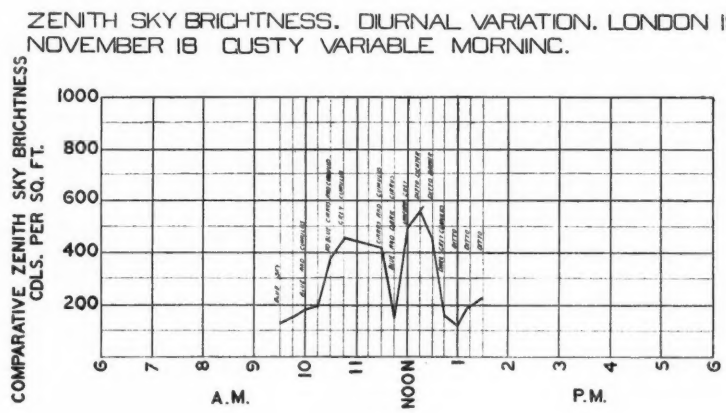

FIG. 5.

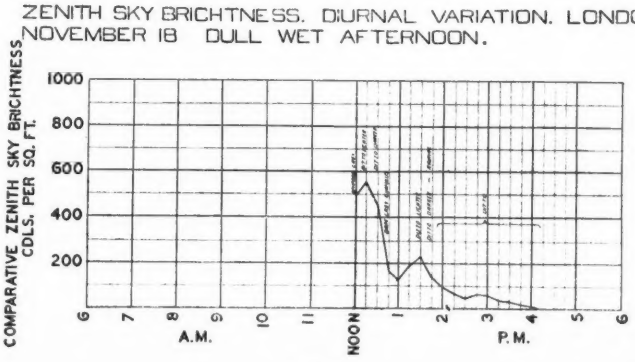

FIG. 6.

tion readily by a single observation is to utilise the ability of the eye to judge the relative brightness of two small similar surfaces receiving low degrees of illumination, one of which slowly varies in brightness, and to determine the point at which they are equally bright.

This is, of course, merely the science of photometry, which has been brought to a considerable degree of perfection during the last few years with regard to the exact measurement of light sources, of the illumination they produce, and of natural illumination. By its means we may hope to correct the fallacies of impressions conveyed by isolated observations, the idiosyncrasies of the eye and the mind, and the errors introduced by the difficulty of allowing for inherited prejudices due to influences which have little or nothing whatever to do with the subject.

The problems of daylight illumination have been studied to some extent, and those which await solution can be defined. An attempt is made herein to marshal them for your consideration, to indicate what has been already done towards their solution, to define certain data which is still required and to suggest some practical means of obtaining it.

The main problems of daylight illumination may be briefly stated as follows :—

(1) What is the minimum natural illumination at which artificial light becomes preferable ?

(2) What are the conditions of minimum sky brightness under which such minimum inside illumination ought to be obtained, or, in other words, what is the minimum ratio which the inside light should reasonably be expected to bear to the outside ?

(3) What are the relative lighting values under various conditions of a square foot of window glass situated at different positions in the wall or ceiling of a given room and with various degrees of obstruction of the total sky hemisphere by surrounding buildings ?

(4) For properly lighting a given point in a room, such as a desk by the wall furthest from the window, what is the minimum angle which the top of the glass should make with the horizontal at that point ; or, what height of window head is essential if the back of a room of given depth should be reasonably well-lighted with given degrees of obstruction by surrounding buildings ?

(5) For lighting a given point in a room, what is the minimum horizontal angle of window glass which should be subtended at that point ; or what width and distribution of window glass is essential in a room of given width with given degrees of obstruction by surrounding buildings ?

(6) To what extent in each case is the illumination affected by the colour of walls and ceilings ?

Before considering these questions either in general or in detail, it is necessary to clearly appreciate that a correct solution of daylight illumination in one case will not necessarily be correct in another, on account of different considerations whose relative importance varies in different cases. The best illumination for reading, writing, drawing and the majority of handicrafts is determined by the physiological fact that our eyes during such operations only take in rays of light which are reflected back from the object viewed, within angles of about 10° or so from the vertical ; and we only see an object by means of the light reflected back from it into our eyes, which is not necessarily by any means all the light falling on to it, or even a large proportion of such light. For the purposes named, low angle light is of minor importance, whereas for other purposes, such as the illumination of wall diagrams and blackboards in a schoolroom, it may be invaluable. Again, a drawing office, a law court or an operating theatre in a hospital might receive the most perfect illumination from a large lantern light which would be all but intolerable say in the wards of the same hospital. In a schoolroom the high angle light which is essential for reading and writing has a most cheerless and depressing effect when it is the sole source of illumination ; and supplementary lighting by window glass at a lower angle, inefficient and uneconomical as it seems as a lighting agent, has a beneficial effect on the minds of scholars which is of no small educational importance. Schoolroom windows which exclude the high angle midsummer sun, whilst admitting what there is of

low angle winter sun, must not necessarily be wholly despised by school architects on account of their poor return in desk illumination; and a patient would probably recover more readily in a hospital ward with comparatively low window cills admitting the early morning and late afternoon sun, than in one which merely gives an excellent vertical illumination to the doctors and nurses. For some purposes a strong and perfectly diffused illumination must be secured at all costs; for other purposes the same perfection of diffusion would be most undesirable. In the workshop of an optician or scientific instrument maker shadows may be highly objectionable, whilst in a modelling studio a certain depth or intensity of shadow may be quite necessary.

A laundry may be best lit by a strong high angle light accentuated by white walls and ceilings, whilst in a needlework room the eye absolutely requires the relief and recuperating effect of soft subdued wall tints, which may possibly discount the illumination to a material extent.

Again, breadth of aspect which might decidedly enhance the rental value of a dwelling room would probably be only distracting in a court of law.

In every case we must weigh the relative importance of factors whose requirements may be different and even contradictory. So that even when we are in a position to determine what size and arrangement of window glass and what minimum obstruction of sky area gives us the best illumination for a given purpose, we must still beware of pursuing ideals too far; and we must apply the touchstone of economic and structural commonsense as we do in every other building problem. A parabolic lattice girder may be the most economical weight carrier; but it is poor economy to save, say, 15 per cent. of rolled steel joists costing 10s. per cwt. by adopting lattice girders at 20s. per cwt. It is precisely the same with lighting problems. In designing a block of offices an improvement in the lighting which might increase the rental value of the lower floors by a problematical 5 per cent. or 10 per cent. would be dearly purchased by enlarging the interior light wells to an extent equal to 25 per cent. of the cubical contents of building otherwise available. It might appeal to our altruistic ideals of good lighting, but our client in his next building would probably cut down his light wells to an excessive degree. To take another instance, it might be decided that the best lighting conditions for schools could only be obtained in one-storey buildings; but to insist on the invariable adoption of that type (probably admirable in country districts) for the enormously expensive sites of crowded towns might so eat up available funds in providing a few excellent new schools that the improvement of old schools, where the childrens' eyes were suffering daily, would be postponed; or the new buildings might have to be so flattened out that the playground areas would have to be unduly decreased and the building walls pushed so close to surrounding buildings that ventilation would suffer.

Available Rules and Data for Daylight Illumination.

Various attempts have been made from time to time to define the essential conditions of good lighting, but the different rules or approximations advocated seldom agree with each other, they do not allow for varying conditions, and none of them, as far as the writer is aware, specify any definite minimum or test illumination. In this country the minimum requirements of the London Building Act, viz.: a glass area of one-tenth of the floor area for vertical lights and one-twelfth for skylights, are frequently adopted as maxima and the now discarded rule for schools of a glass area of one-fifth the floor space for vertical lights is equally respected. As regards permissible obstruction by surrounding buildings, a limiting angle of 45° from a horizontal plane is often regarded, *faute de mieux*, as the criterion of reasonable obstruction.

One of the first and most comprehensive investigations on the subject was carried out by Dr. Basquin in Chicago. In addition to taking daily records of sky brightness over a period of two years (1898-9) he co-ordinated his records with the weather conditions and made a theoretical study of the difficult question of diffuse illumination (Footnote, *Illuminating Engineer* of New

York, 1906-7). Many years previously, in 1865, the late Mr. R. Ker in England had endeavoured to determine the relative value of different portions of the spherical quadrant of the sky visible from any vertical window, and his values are adopted in Molesworth's *Obstruction to Light*, a book published in 1902. Unfortunately these were evidently based upon insufficient data and are quite contradictory to the results of modern investigations, crediting low angle light with greater values than light from high angles. Mr. Molesworth's book however, describes methods of setting out the projection of obstructing buildings on to the spherical surface of sky, upon which surface the path of the sun can be traced. The writer has had occasion to extend the methods suggested and Fig. 7 gives an example of what can be done in the exact estimation of loss of sunlight. It is a case of a window facing south-west by south to which the loss of afternoon sun would be material. The extent of such loss caused by new buildings shown by dotted lines can be seen at a glance. It should be noticed that the shape of the surface of sky obstructed by a building is by no means the same as the shape of the building as seen in a photograph or by our eyes. The semicircular diagram is, of course, a flat projection of the quarter sphere of visible sky from the horizon to the zenith looking in one direction, of which view our eyes and an ordinary photographic lens can only take in about 60° vertically and horizontally. If the sky hemisphere were divided into angular divisions by means of lines corresponding to lines of celestial latitude and longitude, such lines could only be viewed in one direction at a time, and only one of the degrees of longitude would be vertical and the remaining vertical lines would be inclined, whereas vertical buildings to the right or left of the eye would not. For this reason it is not possible to draw the essential lines which show the divisions of the visible sky on an ordinary photographic view and to deduce the loss of sunlight or visible sky therefrom. An opening in a vertical plane, unlike the eye or the camera, can receive light from nearly 180° of sky horizontally and nearly 90° vertically and it looks in all directions simultaneously. The loss of actual visible sky area which is inflicted on it by any building can only be obtained by projecting that building on to the sky. During last summer Dr. Kerr suggested the use of a view finder in connection with the inspection of school lighting, and made an instrument which enabled empirical values to be given to each element of the field of vision. These values were those indicated by the well-known cosine law and could not be readily varied, whilst the picture was an ordinary flat photographic impression. Developing this suggestion, the writer, in co-operation with Mr. Conrad Beck, has recently succeeded in devising a view finder which shows simultaneously the total visible hemisphere of sky subtended at a window divided into angular degrees and the extent to which such sky is blotted out by buildings. The saving of time which this instrument effects in ancient light cases is enormous. Aspect diagrams giving all the angles and planes can be drawn in a few minutes.

If we knew what relative values to attribute to each different element of sky, and what total value was essential to good lighting for any given purpose, we could tell at once either by observation with such an instrument in the case of existing buildings, or by ordinary geometrical projection in the case of new designs, whether any window were unduly obstructed. By similar observation or projection from inside a room lit from a sky which had a given net lighting value left to it by surrounding buildings, it should be possible to determine :—

(1) The size and shape of glass area requisite for the worst parts of the room.

(2) What parts of a room were or were not reasonably suitable for any given purpose.

(3) What annual extra expenditure of artificial light would be involved by any given obstruction to maintain a given minimum during working hours.

(4) To what extent (3) could be mitigated by altering the height of window heads or the colour of walls and ceilings.

As will be shown later it is possible to determine (2) and (3) by direct photometric measurement of the ratio of inside to outside light, and to determine or predetermine (1), (2), (3) and (4) by

direct photometric measurements on models. But photometric measurement in actual rooms is only applicable to existing conditions and is useless for predetermining prospective conditions or for the retrospective comparison of light formerly enjoyed unless the latter has been recorded; whilst model tests, invaluable as they are in ancient light cases, are too tedious and expensive for many purposes. For the inspection of existing schools and workshops, for instance, an inspector would require to place on the window cill some instrument which will show or compute the lighting value of the available sky, then after placing it on each desk or bench to be able to state or record definitely without delay which desks were sufficiently well lit, and which desks, if any, must be condemned; and with regard to the latter whether their defects could be remedied by altering the windows, or whether they were hopelessly irremediable on account of deficient sky area. Obviously, before this can be done we require to know the relative values for lighting purposes of different elements of the sky. In this connection it is assumed that loss of light due to dark walls and ceilings or unsuitable glass are superficial matters which could be rectified at nominal cost.

In the Appendix is given a summary of the conclusions arrived at by different continental authorities, for the compilation and translation of which our thanks are due to Dr. Kerr and Dr. Nash. Whilst feeling the greatest admiration for the work of the talented and painstaking investigators quoted one cannot help a feeling of regret that they should apparently at least have failed in many cases to co-ordinate their findings with any definite standard; and in others to appreciate that the good or bad lighting of a room depends simultaneously upon at least three conditions and not upon any one of them. These are :—

(*a*) The extent or lighting value of the outside sky.

(*b*) The height of window head.

(*c*) The breadth and distribution of glass.

As a basic proposition it may be stated that a certain height of window head is essential to the proper lighting of a given depth of a room, whilst a certain width and distribution of glass is similarly essential to the proper lighting of a given width of room, and that both depend upon the lighting value of the unobstructed sky enjoyed by the window, vertically and laterally. The fallacies of the rough rule making the glass area a certain proportion of the floor area are now generally recognised.

The most important point with regard to existing recommendations is the frequently recurring suggestion that a minimum of sky must be visible from every point of a classroom. Much as one would desire it, this is obviously not essential to good lighting. No one could reasonably assert that English elementary school classrooms, constructed under the rules of the Board of Education, in towns, with an angle of obstruction by surrounding buildings of 30° are improperly lit. Yet in such rooms one can only see the sky at the back of the room by lying down on the floor, and in no class of building with vertical lights is it customary to have such large high windows as in elementary schools. The fact that this devitalises the result of such a large amount of continental experimental research is regrettable, but facts must be faced.

Some years ago when endeavouring to co-ordinate indoor illumination with the sky brilliance which generates it, the writer adopted a method first devised by Mr. A. P. Trotter and constructed an arrangement for reducing to measurable proportions the enormously powerful illumination outdoors, and he measured the ratio borne to it by the light enjoyed in the interiors of many buildings. Details will be found in the ILLUMINATING ENGINEER.*

In a paper read before this Society in 1911† on the effect of wall and ceiling reflections a couple of simple devices were described which are somewhat useful in the practical study of daylight. One is a means of testing under artificial light the accuracy of any illumination photometer used, otherwise than in a laboratory. If a standard candle be lit and placed one foot from a card in an ordinary room, part of the illumination on the

* September and October, 1908, and July, 1909.
† *Illuminating Engineer* (London), May, 1911.

card comes by reflection from the walls and ceilings. This can be measured by screening off the direct light from the flame of the candle with a very small piece of dark material; the illumination then remaining on the card is that due to reflection and diffusion, and when deducted from the first reading leaves the direct light which the card would receive in a proper photometric laboratory with black walls and ceilings.

Similarly the proportion of daylight which is reflected from walls and ceilings at any part of a room can be ascertained by measuring the illumination existing in the shadow of a small black card interposed between the window and the point under consideration.

The writer has also carried out some successful tests to establish the reliability of a suggestion which he made some years ago to the effect that the daylight illumination of a room is the same as that which can be viewed inside any exact scale model of that room facing the same sky and the same obstructing buildings.

Data still required for the Solution of Problems of Daylight Illumination.

(1) *Minimum Illumination.*

Photometric data is needed to determine the value in foot-candles of minimum natural illumination required by average persons. It naturally varies for different purposes.

(2) *Minimum Ratio of Inside to Outside Illumination.*

Some years ago the writer suggested that owing to the large and often rapid fluctuations of daylight, the only exact photometric standard one could take was the ratio of the brightness of the zenith sky to the inside light; and that the only standard, without instruments, was the inside illumination enjoyed at sunrise and sunset on clear winter days at which times the zenith sky is of at least approximately similar brilliance. This is really a very low criterion, the brightness of zenith blue sky being then only about 100 foot-candles in round figures. It is seldom darker than this between sunrise and sunset and is generally much brighter even on wet days in winter in towns. Between sunset and sunrise or when the sky is, in abnormal weather, darker than 100 foot-candles, it would appear to be unreasonable to expect any room to be lit by daylight. It must be noted that the light at sunrise or sunset with a clear sky is increasing or decreasing rapidly. It would not be correct to make such a test at, say, Plymouth without allowing for the fact that the sun there rises or sets 16 minutes later than the calendar time owing to 4° of west longitude. Any test should of course be made at sunrise in a room facing west and at sunset in rooms facing east.

For offices and domestic apartments the following ratios were suggested, viz. :—that the requirements of ordinary comfort cannot be said to be infringed at any point where it was possible to read at sunrise and sunset on a clear winter day. This is equivalent to a ratio of 0·1 per cent. (1/1000) of the light derived from a small portion of the zenith sky, 0·2 per cent. of the total light from an unrestricted full hemisphere of sky of the same brightness, such as would be observed on a white card placed on a roof under a uniformly grey sky, and 0·4 per cent. of the illumination falling on a white card on the window cill with a free horizon.

For schools it would appear that the desirable minimum is somewhat in the neighbourhood of $2\frac{1}{2}$ times as much as in offices, viz. :—that the darkest desk should receive $2\frac{1}{2}$ thousandths (0·25 per cent.) of the zenith light, 0·5 per cent. of the roof light or 1 per cent. of the light on the window cill with a free horizon.

This is equivalent to saying that at sunrise or sunset in a clear winter sky, or at other times when the sky has an apparent brightness of roughly 100 foot-candles, the worst part of an office should receive a minimum of one-tenth of a foot-candle and the worst desk in a school one-fourth of a foot-candle.

Dr. Bishop Harman has suggested 9 foot-candles as a minimum daylight illumination. But this is probably for young children occupying dark places in a schoolroom with very light walls. In ordinary rooms most people find it possible to read fine print under a daylight illumination as low as one-tenth of a foot-candle.

(3) *Relative Lighting Value of different Elements of Sky.*

The writer suggests that this important and even fundamental data can be most easily obtained by placing a large spherical wire cage outside the window of different model rooms and ascertaining the effect upon any given part of the interior produced by blocking out alternate angular divisions of sky. Possibly the relative values thus found might be identical for all ordinary conditions, possibly certain elements might be more valuable in some cases than in others; but even in the unlikely event of a number of different sets of ratios being found to be necessary for different sky can we determine what degree of obstruction will affect any user of given premises. The determination of this obviously affects huge sums, not only of private expenditure, but also of public funds, as in the case of schools, where it is often necessary to determine whether old buildings shall continue, whether they can be improved or must be rebuilt on a new site, and whether they may be extended on the same site to cope with the needs of growing districts.

Relative Values of Window Space in different positions.

The collation of sufficient data to determine this problem from actual

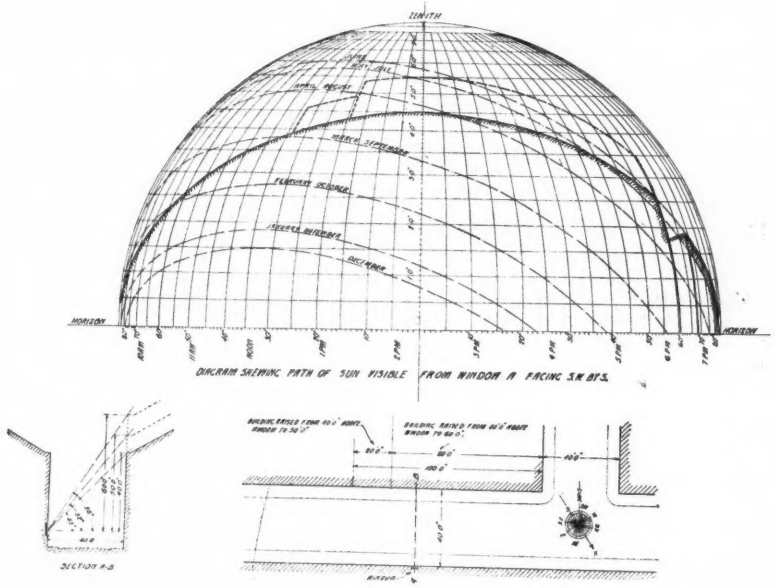

FIG. 7.

conditions of window height and width to depth and width of room, they could easily be printed in the different angular squares of similar diagrams on tracing paper, the appropriate tracing selected and placed over such a diagram as Fig. 7 (recorded or constructed) and the true value of the actual sky lost and retained in any case could be at once computed.

Only when we really know the different lighting values of different elements of rooms would be a stupendous task, and it is fortunate that the daylight conditions of rooms are repeated in scale models in which the effect of different arrangement of window space, wall surfaces and sky obstruction can be studied at a minimum expense. It is also more than probable that an artificial sky could be reproduced by a hemisphere of cotton wool on a wire framework which would give the same photometric

readings under artificial light as a uniformly grey sky; and thus materially reduce the extent of experimental labour, which might otherwise be so tedious that comprehensive results would be almost prohibitive.

The data at present available gives uniform indications that for table or desk illumination a vertical window can only be safely called upon to light a depth of room equal to twice the height of the top of the glass from the table or desk height, viz.:—the space lying below a plane which forms an angle of 26½° with the horizontal from the top of the glass. This, of course, is only in accordance with the ordinary proportions of well designed rooms.

Taking the table height at 3 ft., such a rule would work out as follows:—

Height of Top of Glass above Floor.	Width of Room Lighted.
feet.	feet.
9	12
10	14
11	16
12	18

For schools, an angle of 30° would appear to be preferable.

For windows with northern aspects it also appears that within these horizontal limits of the reasonable range of a window, sky obstruction generally makes very little difference, if any, up to about 60° with the horizontal, measured upwards from the cill; but in portions of a room beyond the proper range of a window the light drops so rapidly that they are sensibly dark by comparison and actually so in dull weather even with a free horizon.

Exact data on this point can be obtained both from experiments on models and by noting the effect of lowering dark blinds in any room.

With regard to the proper width of window for a given width of room and the relative value of lateral sky for lateral lighting, the writer has as yet made but few observations.

The Value of Light Reflected from Walls and Ceilings.

With regard to this important point the amount of experimental data available is also very meagre. Tests of the daylight illuminations on a card placed at different parts of rooms first when unobstructed and then when shaded with a small card which just blocks out direct light from the window glass and leaves only the reflected light tend to show, as would be expected, that at and beyond the "effective range" of a window, light reflected from the walls and ceilings, especially the latter, is a much larger proportion of the total light available than it is in positions nearer to the window, although it is naturally greater there. The writer has not, however, had time to make sufficiently numerous tests on model rooms papered in different colours to be able to give any definite opinion as to the necessary coefficient of reflection in walls and ceiling paper which is essential to keeping any part of a given room up to a given standard.

Additional Artificial Light Involved by Lowering the Daylight Illumination of Rooms below a given Standard.

When we are in possession of large scale time charts showing the average daily variation of daylight it is a comparatively simple operation to state the average daily number of minutes over which artificial light is required to maintain any given minimum daylight illumination at any point in a room, provided we know or can measure the proportion of the outside light enjoyed by that point. For example, if a worker at a table requires artificial light when the natural illumination falls below one foot-candle and the table receives one-thousandth of the outside light, then a diminution of 10 per cent., whether it be caused by dark walls or ceilings, dirty glass, obscured window heads or the raising of surrounding buildings, involves extra consumption of artificial light every morning and evening during the average time which the outside light takes to vary from 1000 to 1111 foot-candles. If this average works out to 12 minutes over the year, then the total average loss at sunrise and sunset is

$$\frac{24 \times 365}{60} = 146 \text{ hours per annum.}$$

The actual loss for most purposes is, of course, very seldom experienced at

more than 300 sunsets per year or 60 hours per annum, and is frequently less than that. Taking the area lit by an average window as equivalent to that lit by a 50-watt lamp, then only 3 units of electricity would be involved. It is obvious that any such computation must generally work out at a very insignificant annual sum, and the plaintiff in an ancient light case would seldom be content to value in such terms the loss to his amenities. On the other hand he generally anticipates that any prospective loss is going to be much greater and more material than it really is.

School Lighting.

The general treatment of this wide subject has left but little space in which to deal with the special branch of school lighting, upon which an eminent architect only a few years ago stated that nothing remained to be said. Yet a Committee of this Society, who, as I have painful reason to know, are extremely enthusiastic and energetic, after having been at work for nearly a year, are still compelled to devote most of their time to the devising of labour-saving systems by which to reduce the great mass of work which still lies ahead of them. Many of their problems have already been indicated, but in addition they have to solve questions relating to unilateral and bilateral lighting, the effect of borrowed lights, the maximum variations between the lighting of various desks, the cure of badly lit existing schools, and the effect of the standing regulations of the Board of Education. Let it be said at once that the latter are in many ways most excellent, and the lighting which they secure in new schools is often all that could be desired. But they do not recognise, however, in their sweeping denunciation of skylights, that in spite of the danger of leaking, these are of enormous lighting value, and can, and do, form a most valuable means of curing at slight expense defects in lighting quite sufficiently atrocious to demand the closing of a school. The regulations also do not differentiate between skylights and lanterns or high dormers; and the emphatic denunciation of front lights is also, to say the least, open to question, at least in cases where the cill is fairly high and the aspect is not sunny. Most of us work facing a window when we can do so.

To adequately treat these questions would probably keep you here till midnight, but the views of school architects would, I am sure, be most welcome to the Committee.

In conclusion, the writer, whilst apologising for the really unavoidable length of his paper, submits for your criticism the general propositions that the subject is one of vital importance, which has been most unduly neglected in this country; that it is one in which study is hampered for lack of practical data; and that the task of acquiring such data, although involving time, trouble and expense, is one which offers rich promise of results of considerable monetary, architectural and medical value. As one who can afford neither the time nor the money necessary for carrying such researches to their proper conclusions he invites the active co-operation of others who are more fortunately placed, and the sympathetic interest of all, in order that this country may take no mean position in a field of research which is of unquestionable vitality and usefulness.

APPENDIX I.—A SHORT HISTORY OF INVESTIGATIONS ON THE NATURAL LIGHTING OF SCHOOLS.

REVIEW OF FOREIGN WORK OF PAST QUARTER CENTURY.

NOTES BY JAMES KERR, M.A., M.D., D.P.H.

THE old-fashioned schools had often small windows, with heavy ornaments about them and diamond-paned glass. No material suggestions were made as to size till the work of COHN in 1866, when from examinations of ease of reading types and the actual performance of the eyes he suggested that the window area in every schoolroom should be at least one-fifth the floor area. As yet there were no photometers available.

Cohn, 1866.

$$\frac{\textit{Window}}{\textit{Floor}} = \frac{1}{5}$$

Javal, *sky to be visible.*

The French ophthalmologist, JAVAL, introduced the idea that from every place in school some sky should be visible, and also in respect to neighbouring buildings that the school should be distant at least twice the height of the building.

French Government, 1882, *Sky equal to* 30 *cm. from top of window.*

In 1882 the FRENCH EDUCATION DEPARTMENT laid it down that from each scholar's place a piece of sky must be seen equal to 30 cm. from the top of the window.

Förster, 1884. "*Öffnungswinkel.*"

FÖRSTER in 1884 suggested the rule that for any desk the angle between a line drawn to the top of the window, and another to the top of the nearest buildings should be 4° minimum. His so-called "Offnungswinkel" or opening angle.

Cohn's "*Raumwinkelmesser,*" *visible sky area to be* 50□°, *giving min. illumination of* 10 *M.K.* (*approx.* 1 *ft.-candle.*)

WEBER introduced his photometer in 1883. Hermann Cohn immediately took advantage of this and made many measurements. Weber further introduced the "Raumwinkelmesser," or solid angle gauge, and using this, too, Cohn pointed out that in 70 schoolrooms 28 per cent. of the children could see no sky.

He worked out that whenever a place had less visible sky than 50 reduced square degrees then in bad weather the lighting was less than 10 M.K., and stated these as the lowest possible requirements for lighting of a school place.

Huth, *Berlin,* 1888.

C. HUTH wrote a paper on Berlin Schools in 1888, generally confirming Cohn's work, pointing out that the eye itself is useless as a photometer, and that almost unbelievable variations are unnoticed by it.

He pointed out that reflections must not be neglected, and that surface reflection of snow might be 0·780, whilst black grey earth was only 0·079.

When the day lighting of the manual training school was 18–19 N.K. there were continual complaints; with 20 N.K. this vanished. In all other classes 25–30 N.K. gave rise to complaints, but 25–30 N.K. was sufficient. It is only children with extreme acuteness who work continuously with 30 M.K. (30 N.K. = 10 M.K. by Weber's photometer).

Wachs, 1889. *Cohn's recommendation rarely complied with.*

DR. OSKAR WACHS in 1889 measured up and published full details of 24 school rooms in Rostock, only four of which came up to Cohn's minima.

An example of his records is the following:—

Classroom 9—

Length, 7·26 m.; breath, 6·18 m.; floor area, 45·08 q.m.; 3 windows with 6 panes with 4·91 q.m. glass area.

$$\frac{\text{Glass area}}{\text{floor area}} = 1 : 9{\cdot}2\,;$$

window, 0·83 m. from floor; 0·21 m. from ceiling. Distance of furthest desk from window, 4·95 m.

Sky visible—

Furthest place 64□° with middle elevation ∢9° = — 256□°.
Middle place 64°□ with elevation ∢26° = — 50□°.
Best place 353□° with elevation ∢29° = + 250□°
(+ or — means less or more than necessary.)

E. Gillert, 1890. "ω *Sin* α" *or* "*Reduced Square Degrees.*"

E. GILLERT made daily measurements in a Berlin school for the whole year. He discussed the work in the light of Cohn's researches, points out the value of the mean elevation of the light beam. When the elevation is 5° then 574□° is necessary, when elevation is 90° only 50□°. The actual square degrees ω multiplied by Sin α (the average elevation) gives reduced square degrees, and this expression ω Sin α is a measure of the lighting of a place (neglecting reflections from walls).

COHN in 1893 reviewed the whole subject in a lecture in Breslau, and restated his 50□° reduced degrees and 10 M.K. as the minimum.

The idea of a vertical 5° of sky with an average elevation of 25° to 27° is now ascribed to Förster in a paper on the use of reflectors for windows in 1892, the reflector being placed at the top of the window.

In 1893 DR. LIEBRECHT reviewed the daylight conditions of all schools in Halle a/d Saale, but does not add anything material to general principles.

1899. A Commission in Berlin recommended that ordinary types should be quickly read at 30 cm.

1901. ERISMANN (of Zurich) wrote a careful and well illustrated paper on school lighting.

In 1901 COHN lectured on methods of photometry, referred to Siemens selenium cell sensitive to light but too sensitive for practice. Vogel's method by silver chloride paper, which reacts to violet rays but not to yellow, so that every light good for vision does not affect it.

Cohn, 1901. *A good photometer needed. Experiments with selenium and photographic paper.*

Andresen of Berlin had used Rhodamine paper, also difficult in practice.

Wingen, a Rhenish architect, used Aristo paper, which was exposed for an hour at one place with 50 M.K. and at other places to be compared. It was then fixed, and the brownness of the piece at 50 M.K. taken as standard. The actual pieces could be put on a plan, and he exhibited specimens.

Wingen, 1902. *"Light-tester" introduced.*

WINGEN introduced his light-tester, and it was at once recommended by Cohn.

At the First International Congress on School Hygiene in Nürnberg PROF. MAX GRUBER of Munich presented a long paper carefully working out the points in day lighting of classrooms. (It was published in the *Gesundheits Ingenieur*, 1904, No. 18.) He recommends first of all roof lighting. Day lighting of a school is only fully assured if it gets direct skylight, although places without this may be nearly satisfactory.

Max Gruber, 1904.

It is necessary to have 50□° reduced sky, and this may be calculated geometrically beforehand (he gives means of simplifying the task for the architect).

Förster's Offnungswinkel and Gotschlick's angles of 4° and 27° Gruber does not accept as satisfactory, as 4° is only sufficient if a minimal horizontal breadth is assured; 27° is also too great. In most Prussian schools, where the height of the window top is 3·20 m. and the width of room 6·0 m., this angle is only 24° 31′.

(*A special summary of this paper is given at the end of this account.*)

About the same time, 1904, GOTSCHLICK wrote a review of methods (*Klin. Jahrbuch*, 1904), describing tests, he accepts Weber's photometer, describes Wingen's chemical method as unreliable, and the photometer as doubtful, and falls back on geometrical measurements with a little sextant. He adopts the 4° and 27° quoted above, but says the area in reduced square degrees is best.

Gotschlick, 1904, *prefers geometrical methods to chemical and photometric ones.*

MORITZ of Halberstadt, 1905, gives records of a series of measurements in reduced square degrees. He finally used an instrument of his own, the details of which I have not ascertained. (*Klin. Jahrb.*, 1905.)

REICHENBACH—Breslau, says (1905) the photometer has less practical value than scientific. The objections of rapidly varying light do not arise with Weber's Raumwinkelmesser. Reichenbach agrees with Gruber in objecting to the opening angle and the average elevation as being unsatisfactory. There is as yet no other sufficient and useful way (than measuring reduced square degrees) for schools.

Reichenbach (1905) *also favours measurement of "Reduced Square Degrees."*

QUIRSFELD of Rumberg (*Prag. Med. Woch.*, No. 13, 1907) made daily measurements in five schools for a year, but adds nothing new.

At the Second International School Hygiene Congress in London FRZ. PLEIER of Karlsbad showed a method he had adopted with a pinhole camera and a solid angle gauge. He has since extended Cohn's calculations for room lighting in several papers.

(*A special abstract of this paper will be found at the end of this account.*)

PROF. POSSEK of Graz (1909) worked at the subject, and found that Pleier's results and Weber's photometer were in agreement.

In the same year the Lumeter, which facilitates rapid photometry, was introduced, and has at once taken a place as a school instrument.

THORNER, in a paper in 1909, describes his small relative photometer.

The idea of relative photometry now came up; it had indeed been suggested by work on models by RUZICKA of Prag,* and was developed into the "daylight quotient" by Pleier, who also worked out theoretically and practically the effect of wall reflexes.

The best method of measurement now is the use of a rapid photometer, such as either Thorner's or the Lumeter, and comparison with the window-sill lighting as a standard.

In a paper read at Buffalo by Dr. M. GSTETTNER of Vienna the effect of blackboards was dealt with, and the American plan of blackboards opposite the window adversely criticised. She had great difficulty with Weber's photometer and light variations.

* Ruzicka found daily variation 8,000–1,000 mk. Assumes 2,000 as average and says minimum on any desk should be 20 (not less than one per cent. of the zenith of intensity). He describes a model for this in detail.

THE DAYLIGHT ILLUMINATION OF SCHOOLROOMS.

BY MAX GRUBER (PROF. OF HYGIENE AT MUNICH).

(ABSTRACT OF PAPER PRESENTED AT THE FIRST INTERNATIONAL CONGRESS ON SCHOOL HYGIENE, *Gesundheits Ingenieur*, NOV. 18, 1904.)

"IF possible the schoolroom should be lighted from above by roof lighting." With a suitable position and sufficient size of lighting openings an equal lighting of the whole room can be attained. Especially to be recommended is the "Shed" roof, as with such an arrangement the direct sunlight can be kept off, and the occlusion of light openings by snow be avoided, as well as the entrance of rain in a downpour.

Unfortunately roof-lighting is only possible in a single storey; when it cannot be obtained then a high side light must be got. The pattern for side lighting is the lighting of a painter's atelier.

We hold a north lighting as best (Bavaria). In any case direct sunshine must be mitigated. . . . According to experience only those places can be safely assured of sufficient lighting from which a portion of the direct sky is visible.

It is not sufficient merely to "see sky." A certain minimum is necessary. The ascertaining of the minimal area is of extraordinary practical importance.

Javal, who first recognised this relationship for lighting, said it would be sufficient if a strip of sky was seen which measured at least 30 cm. downwards from the window top.

Foerster attempted to express this in angular measure. He drew a straight line from the centre of the work place to the outer edge of the top window sill and a second line to the lower edge of visible sky, and called the angle between them the "opening angle." His requirement was that this angle must be at least 5°, with the further proviso that the upper line formed an angle with the horizon at least 25°—27°.

This was an advance . . . as it took in the inclination of the light on the working place, and the amount of light received there is proportional to the line of the angle of inclination.

But neither of the above methods pay any regard to the lateral width of windows.

It can soon be seen that these provisions are not sufficient if the horizontal opening or the highest elevation of window is too little, and may be too much if the window is sufficiently broad.

The correct measure was given by Leonard Weber in his measure by square degrees. Cohn worked out by many observations that any place to have continually sufficient light must receive the equivalent of vertical light from 50 square degrees.

This empirical basis of our lighting schemes is not yet absolutely fixed, and Cohn's statement can only be taken as a provisional rule. Although I believe that for the present we can take it as a normal standard, it certainly does not go too far, and it may yet be determined that it is actually too low.

The determination of a minimum square measure is of great practical value in new buildings, as the dimensions can be reckoned to suit the value wanted. This can be done very easily graphically (as shown in the paper).

Gotschlick has just given a paper on the measurement of this light opening by means of a small mirror sextant and takes the minimum of the opening angle as 4° and of the greatest elevation (top) angle as 27°. He assumes that all windows are broad enough; that is too rosy. (G. works out calculations to show sizes of

windows and area of sky visible, measured both by calculation and by observations.) He concludes that no school place should be more than 4·5—5 metres from window. The innermost places in Munich or Nurnberg rooms have elevation of window top of 25° 7′ 8″, and in Nurnberg 28° 31′ 22″.

The lowest storey is the one which is likeliest to suffer in lighting.

When regard is paid to neighbouring buildings this has to be remembered.

The angle of incidence of light, too, has to be considered ; the steeper this is the smaller the opening necessary.

In a room with window 3·43 metres high the incident light on the far desk will just (top of window) touch 27°, and the lowest sky to give 4° opening will be 23°.

With a steeper incidence, window height being 4·5 m., an opening angle of 2° 24′ 25″ would be sufficient to give the same light as before, whilst with the top of the window reaching 5 metres an opening of 2° 17′ 13″ is sufficient. In the latter cases opposite buildings could be brought up much closer than in the first without affecting light seriously.

Increasing the window height in the lower storeys is the most effective means of improving lighting, and sparing width necessary around building.

Every centimetre of window height is of importance. The height of desks is equally important, and the smallest children should be seated in the lowest rooms. Desks with the feet raised off the floor are bad in this respect, being equivalent to reduction of window height.

A great advantage in school planning is to raise the floors of the lowest classrooms sufficiently to get an earth (cellar) storey suitable for baths, stores, &c., but this is nothing equal in effect to the actual increase of height of room windows on lower floor.

WALL REFLEXES.

A CONTRIBUTION TO THE QUESTION OF SCHOOL LIGHTING

BY FR. PLEIER, Karlsbad.

Zeitschrift für Schulgesundheitspflege, Bd. 1909, p. 227. (Abstract.)

The following factors come into consideration :—

1. The firmament.
2. The walls of neighbouring buildings.
3. The walls of the room.

The illumination of the schoolroom is dependent on the intensity of the light streaming through the windows. It is only a small part of the outside light which comes on the wall and is reflected to the desk. In spite of this wall reflexes must not be left out of consideration, especially in badly lighted rooms. Gottschlick has shown that as a matter of fact the illumination diminishes much less than the square angle of sky visible, and indeed the reflex light becomes proportionately more important the farther from the window.

Pleier shows how to calculate theoretically the influence of each area of wall and then also determined it experimentally. He worked out the effect of the wall in a room (calculating out for each (250 sq. centimetres) element of wall the number of reduced square degrees it subtended at each place). The height of desks was 80 cm., the wall surface 380 cm. high, so that the reflecting surface was 300 cm. high.

The lower part of the wall is evidently most important for desks nearest it, and higher parts for desks farther off. These reflecting surfaces should not be blocked by blackboards, &c.

The essential points brought out in this paper are :—

1. The idea of " reduced square angle," which is usually only taken in relation to the firmament seen through the window, can in regard to any lighted surface be extended to give results as to the lighting of any place.

2. Every square angle can be measured (by instrument) or can be calculated mathematically.

3. The relation between the intensity of a wall reflex (outer or inner) and the simultaneous sky intensity is a constant. This can be measured photometrically.

4. The illumination quotient gives the value of any school place. The illumination quotient is the always unalterable relation between the place illumination and outside intensity.

5. The illumination quotient is the essential symbol for the value of the pupil's place, and offers the means for comparison with other places.

6. The illumination quotient can either be directly measured (or it can be calculated by the formulæ he gives).

APPENDIX II.—NOTES ON INVESTIGATIONS ON NATURAL SCHOOL LIGHTING IN FRANCE AND OTHER COUNTRIES.

PREPARED BY DR. A. E. NASH.

Window Area.

The Belgian Government regulations require $\frac{1}{6}$ window space as compared with the floor area.

In Greece the proportion is $\frac{1}{5}$ or $\frac{1}{4}$.

In Lausanne the proportion is $\frac{1}{4}$.

Truc and Chavernace claim that $\frac{1}{3}$, $\frac{1}{2}$, or even $\frac{2}{3}$ of the floor area is the required window area for good lighting.

Engelbracht suggests the following formula :—

$$f = \frac{F}{5} \quad \frac{t^2}{36}$$

where f = window area in square metres.

F = floor area in square metres.

t = depth of classroom in metres.

Direction of Light.

Trelat emphasises the importance of left lateral lighting, being of the opinion that bilateral lighting causes myopia. Gariel and Javal were of the opposite opinion claiming that lack of light was of more importance than conflicting shadows. Courtious and Dinet proposed to get over the difficulty of bilateral lighting by using frosted glass on the right hand windows so as to diffuse the light.

Trousseau claims that overhead lighting is the best of all.

The French regulations forbid overhead lighting.

Left lateral lighting combined with lighting from the back is approved by Combe of Lausanne, who states that "in all the schools we are able to prove that when the windows placed behind the scholars are large and high up, they are most satisfactory. The whole class is flooded with light, and that of such a character that the shadows thrown by the back windows disappear entirely. The only inconvenience of this system is the nuisance to the teachers, which is practically negligible." This form of lighting is seen at some of the Model Schools at Upsal in Sweden and in the new schools in Lausanne. This system is also used in the newer American schools.

[The remarks of speakers at the last meeting, and also the resumed discussion of this paper at the coming meeting on Jan. 15th, will be published in our next number.—Ed.]

THE LIGHTING UP DINNER AT THE GUILDHALL.

A QUAINT CIVIC SURVIVAL.

The Lighting Up Dinner of the Lord Mayor and Sheriffs' Committee took place at the Guildhall on November 6th. Originally, in the days of the candle, says the *Westminster Gazette*, this formed a very necessary preliminary to the Mayoral Banquet on November 9th. But the rehearsal of the lighting arrangements is now merely, as it were, make-believe, and forms but the excuse for a social reunion of the Lord Mayor and Sheriffs and the Committee who are organising the historic pageant. An interesting survival of pre-gas days.

SOME QUERIES ON DAYLIGHT ILLUMINATION.

As explained in our last issue the following series of queries has been prepared by the Sub-Committee of the Society, dealing with daylight illumination.

We now publish some of the replies so far received, which are also summarised in tabular form on pp. 40–43.

Anyone interested is invited to send information on these points to the Hon. Secretary of the Society (MR. L. GASTER, 32, VICTORIA STREET, LONDON, S.W.).

(1) What measure would you suggest for the minimum actual illumination on the desk for reading in the schoolroom in full (midday) daylight ?

(2) What is the minimum intensity of daylight illumination on the worst-lighted desk in a schoolroom at which you consider that it becomes : (a) preferable, (b) essential to turn on the artificial light in the evening ?

(3) Do you consider a combination of daylight and artificial illumination to be, (a) satisfactory, or (b) inconvenient to vision ?

(4) Under what sky conditions or under what degree of sky brightness should the above minimum daylight illumination be obtained with a free horizon ?

(5) To what angle with the horizontal do you consider that surrounding buildings can be allowed to obstruct the sky hemisphere subtended at the window without materially affecting the light afforded by windows if the latter are of suitable width, and

(a) Subtend an angle of not less than 25° with the back desk,

(b) Subtend any lesser angle ?

(6) Is it desirable to specify that a certain vertical and horizontal angle of sky should be visible from all the desks in a room? What angles are necessary to ensure the minimum illumination under conditions of minimum sky brightness ?

(7) What are the recommendations for dimensions of schoolrooms in your country ? and what regulations are usual with regard to the window area of rooms of a certain size ? Do you consider it preferable to specify that the window glass (but not necessarily visible sky) should subtend a certain vertical and horizontal angle at the back of the room, and what angles would you suggest as desirable in order to obtain the minimum illumination under conditions of minimum sky brightness ?

(8) What is the best method of relating the illumination on the desk in the schoolroom with (a) the unrestricted illumination outdoors, (b) the sky brightness ? Do you think that such data constitute a practical method of comparing the access of daylight into various buildings ; and that they could be made the basis of a specification stating the size of windows and dimensions of schoolrooms ?

(9) What in your experience is the usual variation in daylight illumination met with respectively in the case of the worst and best-lighted desks in a schoolroom ?

(10) Are you in favour of unilateral lighting (windows on one side only) in a schoolroom ? Or do you consider additional windows in the other walls, or skylights (when practicable) also desirable ? In cases where bilateral lighting is unavoidable, do you consider that its effects can be mitigated by skylights or windows at a high angle ?

(11) Do you consider glazed partitions giving light from a well-lit room to one less well lit to be (a) a useful expedient, (b) preferable to a light coloured wall space ?

(12) Do you consider photometric tests in small models of buildings trustworthy as a means of determining the illumination to be derived from windows ; have you any records of such tests ?

(13) Is it desirable to recommend that the walls and ceilings in a room should have a certain minimum reflecting power ?

(14) Have you any other suggestions to make regarding the measurement of daylight illumination ?

SOME REPLIES TO QUERIES ON DAYLIGHT ILLUMINATION (see p. 33).

Prof. L. Weber (Kiel) :—

PRELIMINARY REMARKS.

WHEN, in 1882, I began the measurement of diffused daylight in schoolrooms, in collaboration with Hermann Cohn, we first of all measured the intensity of illumination on the desk surfaces on clear days and at midday.

Although even then I had pointed out the necessity of measuring the sky-brightness at the same time, such measurements were rarely undertaken on account of the tedious calculations involved. In order to characterise the conditions of illumination we contented ourselves with measuring the "Raumwinkel" (solid angle) subtended at each place by the visible sky. If the Raumwinkel, expressed in square degrees, is multiplied by the cosine of the angle of incidence we obtain as a result the so-called "reduced solid angle" ω (reduzierte Raumwinkel). To this quantity the illumination B is related as follows :—

$$B = \frac{\omega}{10{,}313} \cdot H$$

where H denotes the sky-brightness in secondary units,* and B is obtained in metre-candles. The relation B/H is thus determinable once the value of ω for any particular desk is known. For example, if this angle for a certain desk is 50 square degrees, we shall obtain, with a sky-brightness of 10,000 sec. units :—

$$B = \frac{50 \times 10{,}000}{10{,}313} = \text{about } 50 \text{ metre-candles.}$$

If one considers that the sky-brightness on dull days, and during the hours of study most remote from midday, can easily fall below 5,000 sec. units, it is clear that in these circumstances half the above illumination, *i.e.*, about 25 metre-candles, would be obtained. Now as 25 metre-candles is the minimum desk-illumination permissible with us, the above calculation leads to the requirement that *the reduced solid angle at any desk should not be less than* 50 *square degrees.*

In this calculation the light reflected diffusely from walls is left out of account. As would naturally be expected, and as has been demonstrated in particular by Dr. Brillmann,* the contribution of reflected light from walls is often so great that its neglect is not justifiable.

For several years I have therefore reverted to my original idea of *ascertaining, by actual test, the value of the quantity* $q = B/H$ *on any desk in a schoolroom,* and I regard this as the only satisfactory way of characterising this quotient. I have therefore had an apparatus, the "Relativphotometer," constructed, which enables q to be determined with great ease.†

For a desk to receive an illumination of 25 *metre-candles, with a sky-brightness of* 5,000 *sec. units, q will be* 0·005, *i.e.,* 0·5 *per cent. of the so-called unrestricted illumination from a complete hemisphere of sky.*

Expressed in other words, this proposal *specifies the illumination on the school desk as a percentage of the total unrestricted illumination* (*represented by the number* 100q).

It is, of course, necessary to agree that these values should be expressed in terms of some agreed unit of light. For example, if H is known in terms of Hefner secondary units of brightness, one obtains, with the help of q, a value for $B = qH$ expressed in Hefner metre-candles.

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* Prof. Weber has given the following definitions of the primary and secondary units of brightness :—

1 Primary Unit the intrinsic brightness of a surface such that one square centimetre of it yields a light of 1 C.P. (Hefner).

1 Secondary Unit $= \frac{1}{\pi . 10{,}000}$ primary units, and represents the degree of intrinsic brilliancy of a white mat surface, of albedo unity, which receives an intensity of illumination of one metre-candle (Hefner).

* Dissert. Kiel, 1910.

† Schriften des naturwissensch. Vereins für Schleswig-Holstein. Vol. XV., No. 1, pp. 158–162. See also THE ILLUM. ENG., Lond., Vol. IV., 1911, p. 243. This instrument is constructed by Messrs. Schmidt & Haensch of Berlin.

The variations in H during the course of the day and year have hitherto only been somewhat incompletely determined. I have carried out such a determination in Kiel at the hours of 9, 12 and 3 (p.m.) in all months and for sixteen different portions of the sky (S., S.S.W., &c.)*

From these data the illumination at any moment can be predicted. For example, the mean sky-brightness at midday in the month of December in a room facing north-west is found to be 6,140 sec. units (Hefner). A desk for which q had the value 0·5 per cent. would therefore, at midday in the month of December, enjoy the following average illumination :—

$$B = \frac{0{\cdot}5 \times 6{,}140}{100} = 30{\cdot}7 \text{ metre-candles (Hefner)}$$

I may remark that the great simplicity and clearness of these relations is dependent on the use of the secondary unit of surface-brightness. This unit, which has been employed by me for many years, is indispensable in all measurements and calculations of daylight.

Having given the above preliminary explanations, I will now deal with the series of queries submitted to me by THE ILLUMINATING ENGINEER.

(1) If one assumes the " full midday daylight " to correspond with a sky-brightness of 35,000 sec. units (Hefner), the attainment of a desk illumination, B, of 25 metre-candles means that $q = 25/35{,}000 = 0{\cdot}0007$, *i.e.*, 0·07 per cent. The assumed average value of 35,000 corresponds to 12 a.m. in June, in Kiel, where the actual value on record is 34,960 sec. units.

(2) 25 metre-candles (Hefner).

(3) The combination of daylight and artificial light is permissible, if glare is avoided and the surface of the desk is illuminated uniformly.

(4) If by " free horizon " is understood the illumination from an unobstructed sky (the so-called " Ortshelligkeit ") then $q=1$ and $B=25=H$. Such a low sky-brightness as this would be found even with on quite dark winter days and when twilight is quickly approaching.

Remark.—In the foregoing it was agreed that the minimum requirement for sufficient illumination on the school desk was that $q=B/H$ should not be less than 0·005, or 0·5 per cent. of the unrestricted illumination out of doors. This value for q depends on the nature of the window, the presence of obstructions in the form of neighbouring houses, and the colour of the walls of the room. The question arises, therefore, how these factors are to be considered so as to obtain the desired value of q in the case of a school yet to be built. The most complete solution would be to determine the solid angle to be subtended at any desk from a knowledge of the elevation and position of the neighbouring houses, &c. Dr. Hänert* has established some valuable principles to be followed in this work. But such calculations are difficult and will not be willingly undertaken by architects. Probably such problems are more easily solved by experiments on models.

The following method might be comparatively easy. One constructs the façade of a house, with window openings and thickness of wall to scale. This is stood up in a dark room and a small source of light, such as a miniature glow lamp, is placed in the position to be occupied by any particular desk. On the other side of the model wall is placed a white screen, on which the light from the point source is received and a shadow of the window-area cast. Obstructions such as neighbouring houses can then be readily sketched in contour to scale and the approximate value of the solid angle readily determined.

But before such methods can be introduced into practice by architects one must satisfy the existing building regulations. One of the most useful of these is that relating the floor of a room to the window area. The simple ratio window area/floor area (*e.g.*, 1 : 10 or 1 : 5) can be more precisely defined by taking into account the woodwork of the window, and the effect of obstructions such as diminish the actual value of the glass. In my researches on the Kiel schools I have introduced the conception of the " Light-value "

* " Uber die Tagesbeleuchtung der städtischen Schulen in Kiel (Lipsius & Tischer, 1908).

* Dissert. Kiel, 1911.

(Lichtgüte) of the window. By this I understand the ratio between the actual illumination of the vertical window pane and the illumination which would have been received from an unobstructed sky. (Or, what comes to the same thing, the ratio between the solid angle subtended at the window by the visible sky to the solid angle subtended by the sky with free horizon.) For the convenient measurement of this quantity I have made use of a special apparatus (the Projectionssphärograph)* constructed for me by Herr Heusten in Kiel. The factor $P=b.l./g$, where l is the "light-value" defined above, b, the area of the window surface, and g the floor area, is a better approximate quantity to use in estimating the access of daylight into an interior. I have found that in order to obtain a minimum value of $q=0{\cdot}5$ per cent., P in general should have the value 0·08; that is, the glass area should be at least 8 per cent. of the floor area of the room. I believe that this method is the best temporary substitute for actual measurements of the solid angle. The mere specification of horizontal or vertical angles, under which the free sky must be visible, I consider to be theoretically unsound and not to be recommended.

(5) and (6). The specification of certain horizontal or vertical angles should be avoided.

(7) Definite and generally accepted regulations regarding the size of schoolrooms are not known to me. For the rest see reply to (5) and (6).

(8) The determination of the ratio q by the help of the "Relativphotometer" or by experimental or theoretical calculation of the "raumwinkel."

(9) 520 schoolrooms in Kiel studied by me gave as maximum 1,955 metre-candles, and as minimum 8 metre-candles, for a sky-brightness of 10,000 sec. units. (Reduced desk illumination.) The corresponding values for q would be $1{,}955/10{,}000=0{\cdot}1955$, or 19·55 per cent., and $8/10{,}000=0{\cdot}0008$, or 0·08 per cent. Taking the average of the whole 520 classrooms, q for the best, average, and worst lighted places worked out to 7·1 per cent., 2·2 per cent., and 0·8 per cent. respectively. The schools in Kiel have only few windows, by which the lower limit of 0·5 per cent. for q is not reached.

(10) and (11). I can hardly express a definite opinion on this point. But I believe that in general bilateral lighting combined with overhead lighting is permissible.

(12) Actual photometric measurements with models are difficult to carry out, but should be useful. In this connection my proposals in reply to (4) should be considered.

(13) In order to obtain the desired minimum value for q, light wall surfaces are of great value, particularly in cases where adjacent buildings reflect a considerable amount of light.

(14) See preliminary remarks.

Dr. F. Pleier (Karlsbad):—

(1) In my opinion 8 metre-candles would suffice.

(2) If the illumination falls below the above value work should be discontinued or artificial light used. I hold the view that in schools for quite small children artificial light should not be used at all. The teaching scheme should be elastic and it should be brought home to the teacher that if the illumination is insufficient it is better for the lesson to proceed orally.

(3) An actual combination of artificial and daylight illumination, *i.e.*, a simultaneous accommodation of the eye to both forms of light, seems to me in all circumstances objectionable.

(4) The question which is the least intensity of sky for which daylight can still be used is a very important one, but as yet has not been much discussed. I myself suggested at the Congress in Paris in 1910 that a Commission should be appointed to study this subject; but the proposal was not taken up.

It seems to me most important to establish the border line below which artificial light becomes necessary. Without this knowledge further progress in the study of daylight problems is almost brought to a stop.

(5) Exact proposals on this point can only be made with difficulty. Very often much can be accomplished under most

* Schriften des naturwissensch. Vereins f. Schleswig-Holstein, Vol. XIV., No. 2, p. 367.

unfavourable conditions, and the reflecting power of neighbouring buildings, large windows and light walls in a room are all efficacious.

(6) For years there was a recommendation in Germany that each desk should receive light direct from the sky, and that a solid angle of at least 50 square degrees should be available. But it has been shown that in practice this recommendation could not be complied with. It was proved that a desk may be satisfactorily lit if it receives less than the specified 50 degrees and even when it receives no direct skylight at all. One must not forget the effect of light reflected from the walls.

(7) Our regulations prescribe that the schoolroom should, as far as possible, have a south-west aspect. But nevertheless I consider that the best positions are north, north-east, north-west and east.

It is further prescribed that rooms should be at least 3·8 metres high in the country and 4·5 metres high in towns. A space of at least 3·8 cubic metres, or possibly 4·5 cubic metres, should be provided for each student. The length of the room should not exceed 12 metres, and the ratio of length to breadth should be about 5 : 3.

The total area of the window aperture should be at least one-sixth of the floor area, with a free outlook; at least one-fourth in cases in which the sky is obstructed by neighbouring buildings.

(9) The variations met with are unfortunately all too great.

(10) In Austria it is laid down in legislation that the light should come from one side, the left, and three of the walls should have no windows. In France they seem to prefer light being also received from behind or from the right wall. In our country the view is held that this lighting is objectionable.

(11) Glass panes or prismatic glass designed to return light into the room are in general not applicable. Their use is costly, gives rise to trouble in cleaning, &c.

(12) Small models, in my opinion, are not very useful for demonstrating conditions of illumination in rooms. In models one usually gets sharp shadows, and other conditions of illumination which do not occur in actual rooms. The presence of diagrams, cupboards and coloured surfaces of various kinds often modifies the illumination considerably.

(13) Walls and ceilings should be as bright as possible so as to reflect a substantial amount of light. Walls should not be unduly obscured by dark pictures, &c. Reflected light, particularly over the region between 25 and 225 cms. above the desk, is very advantageous for illuminating the least favourably situated desks, and this area should, as far as possible, be left clear.

(14) I may draw attention to other comments contained in my paper entitled "Zur Tageslichtmessung in Schulen" (Zeitschr. f. des Oesterr. Ingenieur und Architekten-Vereins, No. 2, 1908, p. 531); also "Der Wand Reflex" (Zeitschr. f. Schulgesundheitspflege XXII., 1909).

Dr. L. Burgerstein (Vienna):—

(1) 10 metre-candles. Owing to the difficulty arising in comparing such illuminants as daylight and a candle this measurement should be made through a red screen. It appears that 10 m.-c. so measured is equivalent to 25 m.-c. measured with white light in the ordinary way. Such colour comparisons introduce inevitable uncertainty.

(2) (A) 10 m.-c., (B) 6 m.-c.

This minimum will depend on the personal sensitiveness—another source of uncertainty.

(3) I know of no reason why such a combination should be inconvenient. But the human eye is adapted to daylight conditions and we should therefore endeavour to get by artificial light the same intensity as in daylight.

(4) Bright sky.

(5) Say 25 deg. In planning schoolrooms complicated formulæ, such as are apt to be ignored in practice, should be avoided. Thus the requirement for a certain vertical angle might be met by saying that every desk should receive direct daylight; and by specifying generally that the obstruction due to woodwork in the windows should be as small as possible, and particularly that the windows should go up as high as the construction of the room permits.

(6) On the whole opinion favours the rule that each desk should receive a solid angle of sky of 50 square degrees. This angle should refer to visible sky, not window area, and should hold for the worst-lighted desk, *i.e.*, that most remote from the windows.

(7) According to the enactment of the Austrian Minister of Education, June 9th, 1873: The length of the class-room shall not exceed 12 metres . . . the breadth shall be to the length as 3 to 5. . . . The total available window area shall be at least one-sixth of the floor space if the building has a free aspect, and at least one-fourth if the access of daylight is obstructed by neighbouring buildings. The reason why such comparatively large schoolrooms are allowed is doubtless that the law permits 80 pupils per schoolroom in the poorer country districts. As a matter of fact in cities and towns, and even in favourably situated villages, the number of scholars will be much smaller.

(8) The natural method would be to relate the indoor illumination with the unrestricted illumination outdoors, but on the understanding that the sun is not shining on the place of measurement.

Yes. A practical method.

(9) No data of my own. The variations are certainly sometimes very great.

(10) Unilateral (from left) in all rooms where drawing and similar occupations go on and where the shadow cast by light coming from the right might be inconvenient. Bilateral lighting is permissible in rooms where such special work is not undertaken, especially if precautions are taken to minimise the effect of such shadows. Skylights or high windows are useful in this direction.

(11) (A) Useful. (B) Sometimes preferable to light coloured walls, as regards quantity of light furnished; injudicious sometimes for reasons stated in (10), and if placed too low down may be glaring.

(12) Reliability doubtful. Have no records of such tests. The essential point is to ascertain the illumination on desk most remote from window. It might be preferable to build one class-room of normal size, with windows of adjustable size and capable of rotation so as to test the effect of aspect (N., E., S. or W) at different times of day and year.

(13) Yes. Ceiling should be a subdued white, and also the top upper third of walls. Two-thirds of the remaining part of the walls should be painted a light green or yellow, as white would be apt to be glaring to the eyes. The very lowest portion of the walls is of little consequence as far as light is concerned. It is often useful for obstructing walls overlooking a classroom to be painted white with a view to increasing the amount of light reflected into the room.

Dr. Th. Altschul (Prag) :—

In my opinion all measurements of the illumination in schoolrooms are only of technical interest, owing to the great daily and even hourly fluctuations in the intensity. The condition demanded by hygienists is that any pupil having average acuity of vision should be able easily to read the smallest type at present generally used in school text-books, and to write with comfort, even on the worst-lighted desk. I require that the sky should be visible from every desk in the room, and generally that the ratio of window glass area to floor space should be as high as possible.

In all cases I believe unilateral lighting to be the only desirable method. If additional illumination is needed skylights are preferable to windows in the other walls.

In our country (Austria) the usual recommendations are :—

For every pupil: A minimum area of 0·6 square metres and a minimum capacity of 3 cubic metres of air.

A minimum height of room, 3·2 metres.

A maximum length of room, 12 metres.

Mr. G. Widdows (Derby) :—

(1) 8 ft.-candles.

(3) Inconvenient.

(4) Clear sky.

(5) Much depends on contingent circumstances.

(6) Hard and fast rules not desirable. Reflection might give better results.

(7) Height restricted to 14 feet. Net glass, one-fifth of floor area.

Top of glass should make an angle of not less than 30° with back desk.

(8) Yes. Most useful.

(10) Have come across no bad results from bilateral lighting. See the *Builder*, September 19th, 1913, for attempt to meet objections to bilateral lighting.

(11) (A) Yes.
(B) Depends upon proportion of light in the two rooms.

(12) Doubtful expedient.

(13) Yes.

(14) In my opinion the proportion of light inside a room to the light outside is more important than the actual measurements in foot-candles. In artificial light one looks from the bright surface of a book to a dark corner of a room and the eyes are rested. By daylight one looks from a dark corner to a very bright window and the eyes are strained.

Dr. Erisman (Zurich) :—

(1) The illumination on the worst-lighted desk should not be less than 30 metre-candles.

(2) Artificial illumination is necessary when the illumination on the worst-lighted desk falls to 20—25 metre-candles.

(3) A combination of artificial and daylight illumination sometimes cannot be avoided. It is of no consequence if the artificial illumination is sufficient.

(4) The brightness of the sky, when distinctly overcast, should not be less than 200—300 metre-candles. The conditions of direct sunlight and bright clouds are not desirable.

(5) Every desk should receive a certain amount of direct sky light. The angle of inclination should be 20°—25°. If the walls are light in fore and have a good reflecting power, this reflected light can, to some extent, take the place of the direct daylight.

(7) *Primary schools* (6—12 years) : Dimensions 10 × 7 metres. Three rows of seats, each containing 9 double desks, and therefore capable of seating 54 scholars.

Secondary schools (12—15 years) : Dimensions 6 × 7 metres (30—35 scholars). Ratio of window area to floor area 1 : 5.

(9) The following shows the illumination in a typical room :—

Place near window.	Place near Wall.
1031 m.-k.	440 m.-k.
283 ,,	72 ,,
543 ,,	309 ,,
2100 ,,	630 ,,
582 ,,	79 ,,
402 ,,	44 ,,
211 ,,	40 ,,
22 ,,	7 ,,
815 ,,	152 ,,

(10) I am strongly in favour of unilateral lighting (*from left*), on account of the inevitable inconvenient shadows from behind or above. But if very broad windows on the right cannot be avoided they should be just as big as those on the left. Overhead lighting, where practicable, is advantageous.

(11) Light painted walls are certainly to be recommended.

(12) I think photometric measurements with models are not suitable for the calculation of daylight illumination.

(13) It is very important that the walls of a schoolroom should reflect as much light as possible, since by this means a pleasant, well-diffused illumination is obtained.

Dr. Kaz (St. Petersburg) :—

(1) Adequate illumination as indicated on my "individual photometer" (see Internationales Archiv. f. Schulhygiene. The illumination is judged sufficient if type can be read through a dark glass absorbing 96 per cent. of the light).

(2) Artificial light should be used when the illumination, judged by the above instrument, is insufficient.

(3) Of no consequence, provided the intensity suffices for the needs of each scholar.

(10) Yes. In preference to bilateral lighting I advocate the use of rolled prism glass to illuminate the parts of the room most remote from windows.

(14) Attention may be drawn to "physiological photometers," described in paper referred to above.

SOME QUERIES ON DAYLIGHT ILLUMINATION.

Queries :—	Prof. L. Weber* (Kiel).	Dr. F. Pleier (Karlsbad).
(1) What measure would you suggest for the minimum actual illumination on the desk for reading in the schoolroom in full (midday) daylight ?	25 M.K.† (=0·07% of "full midday daylight, 35,000 M.K. [Hefner]).	8 M.K.
(2) What is the minimum intensity of daylight illumination on the worst lighted desk in a schoolroom at which you consider that it becomes : (a) preferable, (b) essential to turn on the artificial light in the evening ?	25 M.K. (Hefner).	(a) 8 M.K. For small children preferably *no* work by artificial light.
(3) Do you consider a combination of daylight and artificial illumination to be, (a) satisfactory, or (b) inconvenient to vision ?	Permissible, if glare is avoided and illumination is even.	Objectionable.
(4) Under what sky conditions or under what degree of sky brightness should the above minimum daylight illumination be obtained with a free horizon ?	25 M.K. available on dark winter days in late afternoon.	Difficult to specify.
(5) To what angle with the horizontal do you consider that surrounding buildings can be allowed to obstruct the sky hemisphere subtended at the window without materially affecting the light afforded by windows if the latter are of suitable width, and (a) Subtend an angle of not less than 25° with the back desk, (b) Subtend any lesser angle ?	Specification of vertical and horizontal angles preferably avoided.	Difficult to prescribe exactly. Local conditions important.
(6) Is it desirable to specify that a certain vertical and horizontal angle of sky should be visible from all the desks in a room ? What angles are necessary to ensure the minimum illumination under conditions of minimum sky brightness ?	See reply to (5).	Doubtful. 50 □ deg. specified but impracticable.

* For fuller particulars see detailed remarks (p. 34).

† M.K.=Meterkerzen. 1 "Meterkerze"=very approx. one-tenth ft.-candle.

Continued on next two pages ☛

SOME QUERIES ON DAYLIGHT ILLUMINATION.

Dr. L. Burgerstein (Vienna).	Dr. Th. Altschul (Prag).	Mr. G. H. Widdows (Derby).	Dr. R. Kaz (St. Petersburgh).	Dr. Erisman (Zurich).
10 M.K.‡	Photometric measurements of doubtful utility. Better to prescribe that small type can be read with ease on worst lighted desk.	8-ft. candles.	Test with "individual photometer," *i.e.* type must be distinguishable through a dark glass absorbing 96% of the light.	30 M.K.
10 M.K.‡				20-25 M.K.
Inconvenient, but reason doubtful.		Inconvenient.	Harmless if light is sufficient.	Unavoidable and harmless if light is sufficient.
Bright sky.		With a clear sky.		With cloudy sky, having 200-300 M.K. brightness.
25°.		Difficult to prescribe without knowing local conditions.		20-25°.
50 □ degrees.	Some sky visible from every part of room.	Hard and fast rules not desirable.	Yes.	

‡ Red Light Method=25 M.K. by ordinary measurement.

N.B.—Replies to Query 14 are not conveniently assembled in this table and should be sought in the contributions in the foregoing pages (pp. 34–39).

SOME QUERIES ON DAYLIGHT ILLUMINATION—*continued.*

Queries :— (*continued*).	Prof. L. Weber (Kiel).	Dr. F. Pleier (Karlsbad).
(7) What are the recommendations for dimensions of schoolrooms in your country ? and what regulations are usual with regard to the window area of rooms of a certain size ? Do you consider it preferable to specify that the window glass (but not necessarily visible sky) should subtend a certain vertical and horizontal angle at the back of the room, and what angles would you suggest as desirable in order to obtain the minimum illumination under conditions of minimum sky brightness ?	See reply to (5).	Regulations as stated in next two columns. →
(8) What is the best method of relating the illumination on the desk in the schoolroom with (a) the unrestricted illumination outdoors, (b) the sky brightness ? Do you think that such data constitute a practical method of comparing the access of daylight into various buildings ; and that they could be made the basis of a specification stating the size of windows and dimensions of schoolrooms ?	Ratio " q " connecting desk illumination with unrestricted illumination out of doors (min. 0·5%). Determined by aid of " Relative-photometer " or calculation from " Raumwinkel."	
(9) What in your experience is the usual variation in daylight illumination met with respectively in the case of the worst and best-lighted desks in a schoolroom ?	In Kiel " q " was for (a) best lighted place 7·1% (b) aver. „ „ 2·2% (c) worst „ „ 0·8%	Variations unfortunately large.
(10) Are you in favour of unilateral lighting (windows on one side only) in a schoolroom ? Or do you consider additional windows in the other walls, or skylights (when practicable) also desirable ? In cases where bilateral lighting is unavoidable, do you consider that its effects can be mitigated by skylights or windows at a high angle ?	Difficult to answer. In general bilateral *plus* skylighting permissible.	In Austria lighting from the left only prescribed. In France otherwise.
(11) Do you consider glazed partitions giving light from a well-lit room to one less well lit to be (a) a useful expedient, (b) preferable to a light coloured wall space ?		Internal glass partitions in general not desired.
(12) Do you consider photometric tests in small models of buildings trustworthy as a means of determining the illumination to be derived from windows ; have you any records of such tests ?	Difficult to carry out but should be useful.	Of doubtful utility.
(13) Is it desirable to recommend that the walls and ceilings in a room should have a certain minimum reflecting power ?	High reflecting power of walls, and also neighbouring buildings, of great value to increase " q."	Light walls desirable.

SOME QUERIES ON DAYLIGHT ILLUMINATION—*continued.*

Dr. L. Burgerstein (Vienna).	Dr. Th. Altschul (Prag).	Mr. G. H. Widdows (Derby).	Dr. R. Kaz (St. Petersburgh).	Dr. Erisman (Zurich.)
Max. length, 12 m. $\frac{\text{Length}}{\text{Breadth}} = \frac{3}{5}$ $\frac{\text{Window glass}}{\text{Floor area}} = \frac{1}{4}—\frac{1}{6}$ 80 pupils per room. 50 □ degrees for worst lighted desk.	*In Austria.* Min. area, 0·6 sq. metres, and min. air space of 3 cub. metres per pupil. Min. height, 3·2 m. Max. length, 12 m.	Ht. restricted to 14 feet. $\frac{\text{Window glass}}{\text{Floor area}} = \frac{1}{5}$ Top of glass should make an angle not less than 30° with most remote desk.		*Primary Schools.* 10×7 m. 54 scholars. *Secondary Schools.* 6×7 m. 30-35 scholars. $\frac{\text{Window glass}}{\text{Floor area}} = \frac{1}{5}$
(a) Good, except in sunlight. Yes.		— Yes. Most useful.		
Sometimes very large.		—		Very variable, but often 1 : 50.
Unilateral for special purposes (*e.g.*, drawing), otherwise bilateral; sky lights useful.	Unilateral best; If insufficient, skylights better than windows in the other wall.	Have met no bad results from bilateral lighting.	Unilateral best. Prismatic glass useful to light more remote desks.	Unilateral. Overhead lighting preferable to windows on right.
(a) Yes. (b) Sometimes, with suitable precautions.		(a) Yes. (b) Depends on proportion of light in two rooms.		Light wall preferable.
Doubtful. Preferable to work with one full-size model classroom.		Doubtful expedient.		Unsatisfactory.
Yes. White ceiling. Upper third of walls white; central third, light green or yellow.		Yes.		Good reflection important.

NIGHT ILLUMINATION OF A SWIMMING POOL.

The Delmar Swimming Pool at St. Louis has recently been illuminated artificially by electric light and the installation was described in a recent number of the *Electrical World*. Twenty-five 500-watt lamps (tungsten) are suspended on cables hung across the pool. This pool is very popular during the summer, and the new lamps have been receiving a great deal of attention. Swimming during the night time is becoming quite a popular pastime; we understand from the Electrical Co. of Missouri, to whom we are indebted for these particulars and the accompanying photograph, that this is the third installation of the kind carried out within the year.

The other two consisted respectively of 5-light tungsten and flame arc lighting, but the arrangement shown above is stated to give much the best results.

HERR ING. ALBERT WEISS.

It is with great regret that we record the death of Herr Weiss, the Treasurer of the National Illumination Commission, which took place at Zurich on December 16th.

All who knew Herr Weiss realise that the Commission has lost the services of one who would have laboured hard for its welfare and who in the past had very ably assisted Prof. Vautier in the work of the International Photometric Commission.

THE ARTIFICIAL LIGHTING OF ADVERTISEMENT POSTERS.

THE increasing number of advertisement hoardings in the streets is a familiar feature of most large cities. The artistic possibilities of such posters have been much developed during recent years; in fact, poster design has become quite a special art.

This being the case, it appears somewhat surprising that in comparatively few cases has any serious effort been made to light up these posters by night. Illuminated in this way, such advertisements become much more prominent objects than in the day-time. They stand out better. It may also be suggested that people walking the streets by night have more leisure to inspect the pictures than they would during the day-time, when business occupies their thoughts.

By the courtesy of the South Metropolitan Gas Co. we are able to show a photograph of an installation in the Company's district, in the New Cross Road, where gas lamps equipped with special reflectors were used to illuminate a series of hoardings. It will be seen that the reflector completely conceals the source from the eyes, throwing the light over the poster, and we understand that it is specially shaped with a view to illuminating the pictures evenly from top to bottom. The length of the hoarding is about 48 ft., and it is about 12 ft. high. There are five reflectors used to illuminate the hoarding, each of which contains three burners consuming 4 cu. ft. per hour each. The total amount of gas consumed would, therefore, be about one-tenth cu. ft. per sq. ft. of surface illuminated. In addition, as will be seen, a considerable amount of light is thrown on the pavement below.

The problem of illuminating large posters is a decidedly interesting one, and we hope shortly to be in a position to give some more precise details. showing the arrangement of these lamps and the intensity and distribution of illumination.

REVIEWS OF BOOKS.

Factory Lighting. By Clarence E. Clewell. (McGraw-Hill Book Co., 239, W. 39th Street, New York, and 6, Bouverie Street, London, E.C., 1913, 156 pages.)

DURING the last few years there have been quite a number of books written on general illuminating engineering. But the time has come for publications dealing with sections of the subject in detail and this volume by Mr. Clewell on "Factory Lighting" seems to be one of the first of this kind.

The first chapter deals with some of the fundamental points to be observed in factory lighting (amount of illumination, avoidance of glare or unsteady lights, &c.). A useful diagram is given showing the over-all dimensions of the chief modern electric lamps.

In the second chapter Mr. Clewell explains the considerations affecting the spacing of lamps. A diagram is presented showing how their height and distance apart should be related so as to avoid inconvenient shadow. It is interesting to notice that the author states the "lighting efficiency" of the average system (*i.e.*, the percentage of the total amount of light concentrated on the working plane) to be between 27 and 30 per cent.

Passing on from design and installation to maintenance Mr. Clewell points out the rapid diminution in efficiency that is caused by neglect. For example, he finds that in an office the diminution in illumination, if lamps are left uncleaned for three weeks, may be about 20 per cent., but in a factory the corresponding loss might be as much as 40 per cent. with glass reflectors. Mr. Clewell makes some suggestions for the maintenance of glassware and shows that the cost of keeping it clean is trifling in comparison with the economic loss through diminished illumination.

The remainder of the book is given up to specific instances of industrial lighting, *e.g.*, offices, draughtsman's tables, power houses, iron and steel mills, &c.

A section is also given up to machine tool lighting. Here, again, an important point demonstrated by the author is that the cost of lighting machines is almost invariably but a trifling percentage —probably less than 1 per cent.—of the wages of the worker. To grudge the small cost of proper lighting is therefore false economy.

The book is well illustrated and contains many hints on factory illumination, which should be useful not only to lighting engineers but to many others engaged in the organisation or supervision of factories.

OTHER PUBLICATIONS RECEIVED.

Kalendar für das Gas- und Wasserfach, 1914. Edited by Dr. R. Schilling. Section on Water Engineering by G. Anklam. (R. Oldenbourg, Munich, Mk. 4·50.)

Internationale Hygiene-Ausstellung, Dresden, 1911. Verzeichins der prâmierten Aussteller.

SONDERKATALOG der wissentschaftlichen Abteilung, Beleuchtung. Prepared by Dr. K. Stockhausen and Dr. W. Friese. Special katalog der Gruppe Licht und Luft. By Dr. W. Friese.

Suggested Definitions of Photometric Quantities. By H. E. Ives. (Reprinted from "The Lighting Journal," New York.)

Christmas and Friday Evening Lectures at the Royal Institution (Albemarle Street, Piccadilly, W.)

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

We notice that the **lighting of railway carriages** is still being energetically taken up in the United States (*Elec. World*, Dec. 21st; *Elec. Rev. and Western Elec.*, Nov. 22nd, and *Elec. Railway Journal*, Nov. 28th). Indirect and semi-indirect methods seem to be coming into fashion, and at Toledo twenty cars have been equipped with three different semi-indirect systems in order to see which appeals most strongly to the public. There is a general recognition that bare lamps are bad and that it is well worth while to use reflectors. With direct lighting very much the same results are obtained whether the light is central or from the side, but there should be one lamp for every two seats to avoid inconvenient shadows. With indirect lighting one lamp for every three seats would be permissible. Semi-indirect lighting is also discussed by L. V. James (*Elec. World*, Nov. 1st), who gives a number of rooms lighted in this way.

In the *Electrical Review and Western Electrician* for Nov. 1st there is an illustrated article on the **lighting of churches.** There seems to be a surprising variety of methods. Lighting from the pillars, cove illumination; indirect methods, overhead lighting through diffusing glass roofs being all employed. The intensity also varies very greatly, being only 0·3 watts per sq. ft. in some cases, but as much as 2½ in others.

An article by Ward Harrison (*Elec. World*, Nov. 15th) deals with **industrial lighting.** The author gives the "utilisation efficiency" of a number of different methods, which varies from 28-60 per cent. Tables are given enabling the illumination from lamps spaced at any desired height to be calculated.

Turning to more scientific matters we may note the article by W. D. Bancroft on the **chemical production of light** (*Jr. of the Frank. Inst.*, Feb., 1913), which contains an excellent analysis of the various methods of exciting light by chemical means and a list of references to researches on this subject.

W. T. Macall (*Electrician*, Oct. 3rd) gives the results of some **tests on half-frosted lamps** and reflectors. In general the half-frosting causes a loss in spherical c.p. of 10-12 per cent. The absorption of one type of Holophane unit proved to be 13 per cent. with both bare and frosted lamps; the efficiency of an opal reflector 16 per cent., with a clear lamp and 17 per cent., with a half-frosted one.

J. F. Forrest (*Elec.*, Sept. 26th) has been making his researches on the **Electric Arc as a Standard of Light.** He still finds that a high degree of constancy is attained but that it is desirable to avoid certain types of carbons which give erratic results.

W. E. and R. Pauli (Ann. d. Physik., July 17th) discusses the possibility of **objective photometry.** It is shown that in some instances the eye may be 1,000 times as sensitive to green light as to red rays, but the exact figure depends on the adaptation of the eye. Experiments were also made with mixtures of coloured light. It appears that two fields may have the same intensity, colour and saturation, and yet may consume a widely different amount of energy; objective photometry is therefore impracticable.

Another method of dealing with **colour photometry** is described by Fabry (*Z. f. B.* Nov. 20th). The method is to use the solutions respectively yellow and blue in colour in varying proportions according to the quality of light to be tested. By putting cells of this solution in front of the standard lamp its colour can be made the same as that of any artificial illuminant, so that the colour difficulty disappears. Allowance could then be made for the absorption of the cells used which can be accurately determined by separate experiments.

ELECTRIC LIGHTING.

Quite a number of articles give particulars of **the half-watt lamp.** The

presence of inert gases checks the deterioration of the filaments and convection currents can be used to carry away the small particles to the top of the bulb where the blackening effect due to such deposits will be of less consequence. The lamps produced in Germany will range from 300-3,000 c.p. and should have a life of about 800 hours.

W. KLEMENT (*E.T.Z.*, Nov. 6th) refers to the **effect of outer globes** in increasing the temperature, and diminishing the life of tungsten filaments. He described a form of reflector which can be fitted direct on to such lamps and makes all outer globes unnecessary.

G. CLAUDE has been giving some additional particulars of the **Neon tube.** He suggests that the colour of the light could be modified by using a small supplementary tube containing mercury, which is also subjected to high-tension discharge. The mixture of light of this colour with that from the Neon tube gives an approximately white light. The *Electrical World* (Nov. 1st) describes an ingenious electrically lighted sign portrait of Mr. Bryan. The electric lamps are placed in recesses so shaped that the illuminated interior stands out and shows the prominent features of the faces, the outer portions, which are not reached by the light, being left in shadow.

GAS, OIL, AND ACETYLENE LIGHTING.

J. W. THORNLEY (*J. G. L.*, Dec. 9th) read a paper entitled **"Notes on Illumination by low-pressure Gas,"** in which a very good summary is given of illumination calculations and the chief factors that have to be considered in predicting the illumination in an interior. Polar curves of a number of well-known units are given and the author shows how the contour illumination curves can be derived therefrom.

Other contributions of the German papers deal with the design and theory of the incandescent burner and LICHTHEIM (*J. f. G.*, Nov. 29th) describes the street lighting by gas in Altona.

F. AHRENS (*Z. f. B.*, Nov. 30th) contributes a well-illustrated serial article describing the application of gas to marine signals, lighthouses, &c.

J. ABADY (*Elec. Times*, Nov. 6th) writes on the possibility of gas and electrical interests eventually combining —a proposition which does not appear so startling as it no doubt would once have done.

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Fabry, Ch. Eine Praktische Lösung für das Photometrieren verschiedenfarbigen Lichtes (*Z. f. B.*, Nov. 20th).

Forrest, J. F. Further Researches on the Electric Arc as a Standard of Light (*Electrician*, Sept. 26).

Gruhn, M. New Method of Illuminating Transparencies (*E. T. Z.*, Aug. 14th).

Harrison, W. Industrial Lighting by Incandescent Lamps (*Elec. World*, Nov. 15th).

James, L. V. Types and Uses of Semi-indirect Lighting Units (*Elec. World*, Nov. 1).

MacCall, W. T. Half-frosted Lamps in Reflectors (*Electrician*, Oct. 3rd).

Pauli, W. E. & R. Uber Objektive Photometrie (*Ann. d. Physik*, July 17th).

Teichmüller, J. Die Photometrische Grundbegriffe für weitere Kreise erklärt (*L. u. L.*, Dec. 4th, contd.).

Churchlighting (*Elec. Rev.*, N.Y., Nov. 1st).

Car Lighting Tests in Toledo (*Elec. Ry. Journal*, Nov. 8th).

A New Development in the Lighting of Schools (*The Builder*, Sept. 19th).

Indirect Lighting of Aberdeen National Bank (*Elec. Rev.*, N.Y., Nov. 22nd).

Deutsche Beleuchtungstechnische Gesellschaft (*Licht u. Lampe*, Nov. 20th).

Moderne Schaufensterbeleuchtung (*L. u. L.*, Nov. 20th, Dec. 4th).

Electric Lighting.

Claude, A. L'Eclairage au Neon (Paper read at Congrès des Ingenieurs Electriciens, d'Angleterre et de France, May, 1913 : supplement to the *Bull. Soc. Int. des Elec.*).

Editorial. Efficiency of Incandescent Lamps (*Elec. World*, Nov. 22nd).

Klement, W. Glockenlose Glühlichtarmaturen (*E. T. Z.*, Nov. 6th).

Schmidt, J. Die Metallfadenlampe kontra Effektkohlebogenlampe, und die Dreikohlen-flammen bogenlampe (*Z. f. B.*, Oct. 20th).
Die Halb-watt Lampe (*Z. f. B.*, Oct. 20th ; *L. u. L.*, Dec. 4th).
Die Lelios-glühlampe (*Z. f. B.*, Oct. 20th).
The Nitrogen filled Tungsten lamp (*Electrician*, Oct. 10th).
An Electrically Lighted Shadow-portrait (*Elec. World*, Nov. 1st).
Eclairage électrique des trains (Système Tudor), (*Electricien*, Nov. 1st).

Gas, Oil, and Acetylene Lighting.

Abady, J. Will Gas and Electrical Interests Combine ? (*Elec. Times*, Nov. 6th).

Ahrens, F. Die Gasbeleuchtung für Seezeichen (*Z. f. B.*, Nov. 30th).

Editorial. Scientific Applications of Gas (*J. G. L.*, Dec. 9th).

Gilpin, F. H. Automatic and Distance Lighters (*J. G. L.*, Dec. 2nd).

Grazion, R. Eclairage à l'Acétylène par installations fixes (*Rev. des Eclairage*, Oct. 31st).

Lichtheim, . Strassenbeleuchtung vermittelst Gasstarklicht in Altona (*J. f. G.*, Nov. 29th).

Sautter, L. Gasversorgung unter Anwendung von erhöhtem Druck (*J. f. G.*, Nov. 8th, 29th).

Thornley, J. W. Notes on Illumination by Low Pressure Gas (*J. G. L.*, Dec. 9th).
Gas Lighting of Railway Carriages (*J. G. L.*, Dec. 2nd).
Die Beleuchtungsindustrie und der Entwurf des neuen Patentgesetzes (*J. f. G.*, Nov. 22nd).
Acetylene for Railway Carriages (*Acet. Lighting and Welding Jr.*, Dec.).

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
J. f. G.—*Journal für Gasbeleuchtung.*
L. u. L.—*Licht und Lampe.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

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1914

GREETINGS

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and Staff of the

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A

Prosperous New Year.

TRADE TOPICS.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

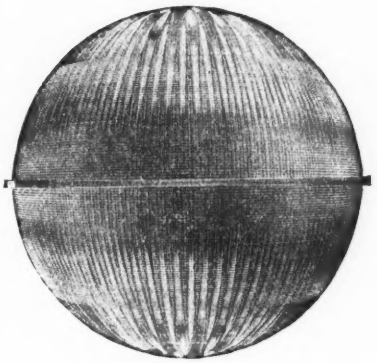
The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

HOLOPHANE STILETTO SPHERES.

The illustration shows the general appearance of the new **Holophane** Stiletto Spheres, particulars of which have just reached us. We notice that the polar curve of these units is practically identical with that of the old spheres, but the use of Stiletto prisms is considered to give an even more decorative effect.

Spheres of this type are listed in four sizes, (respectively 10-in., 12-in., 14-in. and 16-in. over-all diameter), and are adapted to the use of metallic filament lamps consuming 60–300 watts.

We have also received copies of the newly issued list of Holophane fittings for spheres, reflector bowls and semi-indirect bowls, &c. Another recently issued publication is a general index which gives the pattern number and price of all the chief Holophane units.



The New Holophane Stiletto Sphere.

EDISWAN PROGRESS.

The Edison and Swan United Electric Light Co., Ltd. (Ponders End, Middlesex), draw our attention to several important contracts recently secured by the Company.

Two battleships, one a Turkish boat, and the other British, namely H.M.S. "Emperor of India," are to be lighted throughout with Royal Ediswan Electric lamps. The order consisted of nearly twelve hundred lamps.

The Company have also secured an important contract for a supply of lamps to the Caledonian Railway Co.; we understand further that Ediswan lamps were used for night lighting on the scaffolding in front of Buckingham Palace during the recent renovations—a severe test of strength and durability.

BANK LIGHTING WITH X-RAY REFLECTORS.

With reference to the account of the novel method of indirect lighting in some Chicago banks which appears on page 8 of this number, we are asked to state that the installation in the Swedish American Bank was carried out by Messrs. The Pearce Electric Co. of Chicago, and that the architects were Messrs. Ottenhaimer, Stern & Reichert, also of Chicago.

The architects for the building of the Union Trust Co., a view of which was also shown in the article, were Messrs. Marshall & Fox, of Chicago.

WOTAN HALF-WATT LAMPS.

On Wednesday, Dec. 10th, an opportunity was given to the press to inspect the new half-watt Wotan lamps at the Works of **Messrs. Siemens Bros. Dynamo Works** (Tyssen Street, Dalston, N.E.)

One of these lamps was shown in actual operation. The most interesting feature of these new lamps is the novel arrangement of the filament, which is in a stout spiral form and burns in an atmosphere of inert gases. It is stated that these half-watt lamps will very shortly be placed on the market in sizes ranging from 600–3,000 c.p. (300–1500 watts).

The filament is wound in zig-zag form, and, being quite a long distance from the lamp-holder, there is little obstruction of the light. The normal c.p. of the lamp is stated to be equal to the mean lower hemispherical c.p. Apparently at the commencement of its life the c.p. in the upper hemisphere would be nearly the same. But presently, owing to the convection currents set up in the bulb, the upper portion of the glass blackens somewhat and this of course reduces the light above the horizontal. It appears that very little blackening occurs in the *lower* part of the bulb, so that the light in the lower hemisphere is very little affected.

It is anticipated that the new lamps will have a life of about 1,000 hours. They should lead to important developments where high-power units are desired, and they will doubtless prove particularly serviceable for use with indirect and semi-indirect fittings.

Messrs. Siemens Bros. also inform us that they have obtained a contract for a supply of Tantalum and Wotan drawn wire lamps for the Metropolitan Railway during the coming twelve months. Contracts have also been placed by the Canadian Northern Railway for the supply of Marine Traction Tantalum lamps for use with their Atlantic Steamship service vessels.

NEW B.T.H. FITTINGS SHOWROOM.

We notice that the British Thomson Houston Co. have opened a new fittings showroom at Mazda House, Upper Thames Street, E.C.

An interesting feature is the combined exhibit of indirect pendant fittings, wall-brackets, historic table lamps and novel table decorations.

The display should be of interest to many electrical contractors.

INCANDESCENT ACETYLENE LIGHTING.

The Fallot Incandescent Light Co., Ltd. (27, Noel Street, Wardour Street, W.) send us particulars of their system of incandescent acetylene lighting. The essential point in the system is the concentration of an oxy-acetylene flame on a small pastile of incandescing material. By this means a steady and powerful light is obtained. An important advantage is the fact of the light being concentrated in a small point which makes it very advantageous, optically, for searchlights, motor-car headlights, and lantern and cinematograph projection. Dissolved acetylene is very conveniently used for such purposes. One cylinder lasts quite a long time. Thus with the oxy-acetylene light the cylinder would last for 10-20 hours, and can be easily exchanged and refilled if necessary.

Particulars are also given of Fallot Generators. The method is expected to have important applications to cinematograph displays.

WELSBACH ADVERTISING LITERATURE.

The Welsbach Light Ltd. (344–354, Gray's Inn Road, W.C.) send us a selection of their publicity literature, posters, &c. An interesting item is the booklet entitled "Welsbach Advertising" which contains the series of pictorial advertisements that have been appearing in the daily and weekly papers. Many of the posters are familiar, notably the one showing the surprise of the inspector at the low meter rate. The explanation given is "The meter is all right, Joe, it's those Welsbach mantles!"

MR. SALOMON FALK.

We regret to record the death of Mr. Salomon Falk, a founder and Managing Director of Messrs. Falk, Stadelmann & Co,, Ltd., which took place on the 29th November. Mr. Falk was one of those instrumental in forming the company in 1887 and did much to bring it to its present stage of prosperity.

2

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON · GASTER

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EDITORIAL.

Daylight Illumination.

In this number we summarise the further discussion of Mr. Waldram's paper on Daylight Illumination. At the last meeting of the Society several important new matters were brought up. There was firstly, the "sill-ratio" (*i.e.*, the ratio between the illumination on the window-sill of the schoolroom and the illumination on the desk most remote from the window), dealt with by Mr. Clinton. This was considered a promising method of determining the access of daylight into schools.

Next, there were the experiments conducted by Mr. Waldram and Prof. Clinton with the object of ascertaining how far it is possible to predict, by experiments on small models, the actual daylight conditions in an interior.

Finally, there was the "indicator-photometer" suggested by Mr. A. P. Trotter as a means of signalling when the daylight illumination in a room has fallen to the point at which artificial illumination becomes essential.

These methods are so novel that it is difficult as yet to appraise their practical value. To many engineers well acquainted with problems of artificial lighting the subject is quite unfamiliar. Even those Continental authorities who have made a special study of the subject evidently differ radically in their opinions. The replies to the series of queries published in our last number should, we think, be of interest to many of these experts. By assembling these divergent views in tabular form, one reveals clearly where there is a consensus of opinion and where there is disagreement.

The fact that so many experts have been independently working on the subject shows that natural illumination is a vital factor in our daily life, and we feel sure that anyone who has read the discussion of Mr. Waldram's paper must appreciate this fact. It must be owned that daylight illumination is of great consequence to the Illuminating Engineering Society and to the lighting industry. Artificial illumination is contrived simply and solely as a supplement to natural illumination and should be considered with it. There is no abrupt break between the two. In all buildings there comes a twilight period, when the transition from natural to artificial light has to be made. During the winter we may even start the day by artificial illumination, change over to daylight and finally go back to artificial light again. It is probable that the eye is, physiologically, in a very different state during the day from what it is by artificial light.

The human eye has been evolved in such a way as to make the best use of daylight. Clearly, therefore, it is essential that engineers who have to deal with artificial lighting and have to design installations so as to be pleasing and agreeable to the eye, should study the daylight conditions on which the constitution of the eye so greatly depends. *To put the matter shortly, the eye has been developed to suit daylight, and artificial lighting has to be developed to suit the eye. Therefore the arrangement of artificial lighting is essentially connected with the study of daylight, and depends on its intensity.*

In any case it should be remembered that by far the greater part of the work of the world is still done by daylight and not by artificial light. It is true that the provision of natural light is determined very largely by the architect who schemes out the building, but the scientific study of window space, the treatment of ancient light cases, &c., all involve problems connected with the intensity of light and photometric processes which are essentially matters with which our Society ought to deal.

The problem of distributing daylight illumination in buildings, involving as it does the design and use of mirrors and prismatic glass and the consideration of reflecting surfaces, is essentially a field for the skill of the illuminating engineer.

Sunlight also exercises an influence on the mind and body quite apart from its utility in enabling us to see surrounding objects. Medical men have long insisted on its germicidal properties, its value in combating tubercular and other diseases, and the wholesome influence it exerts in the direction of cleanliness. A building which has bad natural lighting is apt to become dirty, and its inmates, being accustomed to the imperfect illumination by day can rarely be induced to instal satisfactory artificial illumination by night.

Again, we constantly find that the representative of some system of lighting claims as an advantage that it is "nearest to daylight." It is idle to make such a claim and yet to contend that daylight, on which the artificial light is supposed to be modelled, is not worth studying. On the contrary, it should be our business to find out the good and bad points of daylight, and to draw our conclusions as to what we should imitate and what

we should avoid in connection with artificial light. In the future we shall surely find that any regulations or legislation affecting the lighting of interiors will apply both to natural and artificial lighting. We constantly find that the subjects overlap. For example, the question at once arises whether the minimum illumination desirable for safety and the minimum illumination necessary for certain processes will be the same by daylight as by artificial light. If not, why not? Then again, the question must arise, especially in connection with schools, offices and factories, at what time in the day ought artificial light to be turned on and artificial light substituted for daylight? If we could establish the value beyond which artificial light is essential a great step forward would be taken, and the suggestion of Mr. Trotter, that it might be possible to provide an "indicator-photometer" showing when the time to turn on the artificial light has arrived, is one that we may presently see realised.

The shape of buildings is to a very large extent settled by the question of providing sufficient daylight. A building ought, strictly speaking, to be designed according to the purpose for which it is intended. For example, the shape of a schoolroom is fixed almost entirely by the position of the windows, and many spinning factories in the north are erected almost entirely with a view to maximum window space.

Now this shaping of buildings imposes considerable limitations on the artificial lighting. In the future, no doubt, it will be recognised by architects that the design of buildings ought to be influenced by the artificial lighting to a far greater extent than at present. In many cases the conditions may be such that it is really impossible to provide adequate daylight illumination, and it would, therefore, perhaps be better if the architect devoted himself to scheming out the building mainly with a view to making better use of artificial lighting.

At present the study of daylight illumination is in a state of flux. It is easier to present problems than to suggest solutions. Comparatively few people have studied the subject from the "illuminating engineering" standpoint; the Society is therefore fulfilling its objects in bringing about the closer investigation of this most important subject.

The Coming of the Half-Watt Lamp.

The coming of the half-watt lamp has naturally excited keen anticipation and interest, and in this number we publish announcements by several firms that they are now prepared to supply these lamps in the open market.

No doubt the half-watt lamp will exercise a marked influence on electrical illumination. We understand that for some time to come only lamps of comparatively high candle-power will be available, and the tendency may, therefore, be to utilise larger units indoors than have hitherto been customary. For large halls and lofty rooms generally the new lamp will naturally be specially well adapted.

The introduction of these large units should have a marked effect on the design of fixtures and glassware. We imagine that it will accentuate

the present tendency to use large hanging globes and bowls rather than chandeliers carrying a considerable number of small lamps. Globes and bowls of exceptionally large dimensions will be necessary to suit the more powerful lamps, and we have recently seen some striking examples of scientific glassware designed to break up, soften, and redirect their rays.

One point is obvious. In order to get the best effect from the new lamps good methods of shading will be essential. It is now generally accepted that the ordinary tungsten lamps require some form of shade to moderate their brilliancy; the introduction of metal filament lamps gave quite an impetus to scientific shading. But the intrinsic brilliancy of the half-watt lamp is known to be far greater than that of the ordinary tungsten lamp.

It is hardly likely, therefore, that people will be inclined to use it without some form of shade, unless it is hung at a considerable distance from the eye. Even in this case the necessary direction of the rays will call for some form of reflector. Probably the new lamps will also be conveniently employed in connection with semi-indirect lighting and, even so, should enable a higher illumination to be obtained with a given consumption of electricity than at present.

We anticipate, therefore, that there will be a keen demand for scientific glassware designed to suit the new lamps, and some attractive designs are already making their appearance.

Public Demonstrations of Good and Bad Lighting.

On page 64 we give an account of a novel exhibit organised by the American Illuminating Engineering Society at the National Exposition of Safety and Sanitation, held in New York last December.

The exhibit took the form of a series of eight booths each devoted to some specific branch of lighting and illustrating the fundamental rules of good illumination, and we understand that these demonstrations proved most attractive to the visitors.

The fact of such a display being organised in connection with an exhibition given up to Safety and Sanitation is significant. We note that at the close of the Exhibition the entire exhibit was removed and placed in the American Museum of Safety. The progress of this Museum is due mainly to the enterprise and energy of its director, Dr. Tolman, who has travelled all over the world studying industrial safety devices, and who is so ably assisted in his work by Mrs. Tolman; and to the genial President of the Museum, Mr. Williams,. In the course of his travels Dr. Tolman was led to appreciate the great part played by good illumination in the factory and particularly in regard to the health and safety of employees.

We believe that the Home Office in this country have also in view the organisation of a Museum of Safety similar to that existing in New York. When this comes into being some exhibits should be prepared illustrating the important part played by illumination in promoting the safety of the industrial worker.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(A REPORT PRESENTED AT THE SEVENTH ANNUAL CONVENTION OF THE AMERICAN ILLUMINATING ENGINEERING SOCIETY, PITTSBURGH, PA. (U.S.A.), SEPTEMBER 22-26TH, 1913.)

(*Continued from p. 7.*)

Photometry.

The search for a primary standard of light still goes on, and the requirements for one have been the subject of papers appearing from time to time during the past year. But little actual progress in this direction has, however, been made public.

At the last meeting of the German Illuminating Engineering Society, however, a paper was read discussing the question of an absolute standard, and it was proposed to investigate the distribution of energy in the spectrum of the source of light to be investigated, to determine the sensibility curve of the human eye for different wave lengths, and to calculate therefrom the distribution of light intensity in the spectrum, and finally to arrive at the total candle-power. An extended discussion of the possibilities of using the black body as the basis of a rational unit of light followed the reading of this paper.[51]

The past year has been noteworthy in regard to the paucity of published reports on secondary standards. In the National Physical Laboratory of England a set of twenty-four tungsten substandards running at 1.5 watts per candle has now been established on a satisfactory basis. The values of candle-power which are now assigned to these lamps have been determined by a "cascade" method by six different observers, the work having been in progress for about three years. In the cascade method it was found that the mechanical errors and those due to changes of observers from day to day have given rise to a probable error of 0.08 per cent. The possession of a series of substandards graded in the hue of the light emitted has been found a valuable asset in the testing of lamps of different types in enhancing the accuracy and facilitating the testing of such light sources as acetylene lamps, gas mantles, flame arcs and metallic filament lamps of all kinds.[52]

Tests were also made upon helium tubes, which indicated that the maximum deviation in the tubes tested, and which were selected with care as to uniformity of bore and thickness of wall, was 3 per cent. The chief improvement now to be sought is complete freedom from striations.

In phases of photometry other than in regard to standards, the work during the

[51] *Journal für Gasbel.*, July 12th, 1913.

[52] *Electrician*, June 27th, 1913.

past year has been on greatly varied lines. Conveniences in working the present type of photometer, selenium and other photo-electric cells, the reliability of the flicker photometer, and the application of the radiometer have all been the subject of study.

The photo-electric cell particularly has received much attention. Of great importance is the development of a new form by the pioneer investigators of this cell, in which the alkali metal surface is covered by a layer of hydride. This is made permanent by filling the glass bulb with a rarefied atmosphere of argon or helium. These special cells possess extremely great sensibility.

Recent experiments undertaken to determine the relationship between the photo-electric current and the intensity of illumination have shown a direct proportionality over a range of illumination from about one-third that due to full sunlight down to the lowest illumination detectable by the eye.

Other experiments have had for object the explanation and elimination of a number of disturbing factors variously called dark currents and contact electromotive force effects. It now appears probable that in the photo-electric cell, when completely developed, we shall have an objective photometer of very satisfactory character.[53]

The selenium cell has been developed to such a point that it gives excellent results with monochromatic light, provided the exposure is short. An accurate sensibility curve has, moreover, been established from which it was found that the cell was most sensitive to yellowish-green light under faint illumination, and to red light under strong illumination. The relations are, however, so complicated that, except for monochromatic light the selenium cell is as yet impracticable for photometric work.[54]

The efficiency of a selenium preparation used as a detector of light may be defined as the amount of additional conductivity imparted to it by the unit of incident light. Later investigations show that the total effect of the light action is shown to be proportional to the square root of the incident energy, while the instantaneous effect is proportional to the energy. This is verified down to an illumination of 0.00001 meter-candle. It is shown that selenium is the most efficient light detector known, and is capable of discriminating minute differences of luminous intensity far beyond the capacity of the eye.[55, 56, 57].

Colour photometry has of late occupied much attention. A chromoscope was devised a couple of years ago in which the colour could be determined in terms of the colours obtained from the standard quartz plates by polarized light. In a newer instrument four numbers are required to designate the colour under test as to tone, saturation and brightness. The quartz plates are in two systems, but a wide range of colour measurement can be made using one system only. The author of the article describing the instrument considers it of the greatest advantage that a colour can be reproduced at any time from its four characteristic numbers alone.[58]

A series of experiments made to ascertain the form of optical instrument most suitable for colour measurement showed that any colour could be imitated by the admixture in suitable quantities of the lights of three suitably chosen narrow regions of the spectrum. Instead of adding these coloured lights, broader primaries may be subtracted from the white light by the selective absorption of suitably chosen dyes, but in this case the difficulty of expression becomes serious owing to the impossibility of securing dyes which will absorb one primary region and transmit the remainder of the white light in equal proportions.[59]

About a year ago a simple method of comparing the colours of artificial illuminants was described, based on the observation of their comparative intensities through a photometer. In the eye-piece of the instrument blue, green, yellow, red and deep-red glasses are inserted successively, and in this way comparisons

[53] *Physik. Zeitsch.*, August 15th, 1913.
[54] *Electrician*, December 6th, 1912.
[55] *Electrician*, July 11th, 1913.
[56] *Proceedings* Royal Society, August 19th, 1913.
[57] *Elec. Rev. and West. Elect.*, February 1st, 1913.
[58] *Ann. der Physik.*, October 15th, 1912.
[59] *Proc. Phys. Soc.*, October, 1912.

were made of the spectrum intensities of these colours.[60]

In connection with colour photometry, the flicker photometer has received its share of attention and a discussion has taken place as to whether this type does actually measure relative light intensities. It has already been pretty well established that it gave more consistent results when used to measure lights of dissimilar colours, but there was a question as to whether there was not a "luminosity sense" distinct from the "colour sense."[61] Recent careful investigations indicate, however, that the flicker photometer gives true brightness, although it gives at low intensities a reversed Purkinje effect which makes it necessary to use caution in its employment.[62]

It has been suggested that the physiological process, which affords the common basis by which coloured and uncoloured lights are measured by means of the flicker phenomenon, is the contraction of the iris when exposed to bright light. According to this the flicker adjustment would be complete when the iris has no tendency to alter under alternating illumination. An experiment was made in which the irises of the observers were paralyzed with a solution of homatropine sulphate. The appearance of the flicker was, under these conditions, just the same as when seen by normal eyes. All degrees of flicker remained as before the atropine was placed in the eyes, and it was noted that the disagreeable quality of the coarse flicker persisted undiminished. Moreover the numerical results obtained for each eye and for each observer agree very well among themselves.[63]

One writer claiming to have a practical solution of the problem of heterochromatic photography describes absorbing liquids, definitely specifiable, which may be used in varying thicknesses and proportions to make the light of a given standard like that of any other illuminant. A yellow and a blue solution have been found which suffice to match all the ordinary illuminants with a Carcel; a purple solution is suggested for use where these are not sufficient, the three absorptions giving by the three-colour principle all the tints as represented in a colour triangle.[64]

A suggestion made to eliminate colour difference in the photometry of incandescent lamps is to run the standard lamp at such a voltage that its colour corresponds to that of the lamp under test, and then determine the candle-power of the standard from a previously plotted curve of candle-powers and voltages.[65]

To the number of illuminometers already on the market has been added still another. This consists of a box containing a small standardized tungsten lamp at one end and a bunsen screen at the other. On one side of the box is a sliding rheostat connected in series with the standard lamp and provided with a pointer indicating on a scale the illumination on the screen in foot-candles, the adjustment being made entirely by varying the resistance. Two scales are provided, one reading from 0.3 to 10 foot-candles, the other from 0.001 to 0.3 foot-candle, corresponding with the application of 4 and 2 volts respectively to the standard lamp.[66]

Still another recent illumination photometer consists of a Lummer-Brodhun arrangement with lateral windows to which are attached two rectangular tubes, one directed toward the screen upon which the illumination is received and which may be set at any angle and in any plane, and the other terminating in an elbow leading to a standard tungsten lamp, in which elbow is set a standard reflecting screen; in this photometer the standard tungsten lamp is movable travelling along a scale.[67]

Another photometer, depending upon the acuteness-of-vision, comprises a white wedge illuminated by the light to be tested. Between the eye and the illuminated area is placed a glass screen on which a diagram of very fine lines is marked out. In comparing two lamps the observer merely moves the photometer back and forth until the lines

[60] *Good Lighting*, August, 1912.
[61] *Philos Mag.*, November and December, 1912.
[62] *Electrical World*, April 19th, 1913.
[63] *Philos Mag.*, July, 1913.
[64] TRANSACTIONS Illuminating Engineering Society, June, 1913.
[65] *Electrical Review* (London), November 15th, 1912.
[66] *Illuminating Engineer* (London), December, 1912.
[67] *Illuminating Engineer* (London), September, 1912.

become perceptible and notes the distance from the source. In order to prevent imagination from assisting the eye, the lines may be rotated so that the observer does not know their position. The method is said to give satisfactory results, but allowance has to be made for the effect of adaptation on the eye.[68]

During the year attention has continued to be given to photometers adapted to the newer requirements of the incandescent lamp industry. Two watt-per-candle photometers have been described having for their object determination of the voltage at which the lamp under test will give the desired efficiency rather than the candle power, as was the former practice. One of these is noteworthy in that the operation of the instrument is exactly parallel to the operation of the formerly widely used candle-power photometer as used upon single circuit fluctuating voltage.[69]

Another watt-per-candle meter has been devised based upon the principle that if two potential differences are equal as indicated by a galvanometer, then the two lamps are at the same watts-per-candle. If they are different the variation in a resistance, required to make them equal, is a measure of the ratio of the watts-per-candle of the two lamps.

A rather novel method of reducing the quantity of light for photometric purposes was described in a paper read before the German Illuminating Engineering Society. If the light used for illuminating the surface under test be reduced by placing in its path an opaque disc with an open sector, the illumination of the surface will not be uniform if the disc is stationary. The author, therefore, lets the light passing through the sector be received in an Ulbricht sphere, the inner surface of which is uniformly lighted by reflection as far as it is not illuminated by incident light. To complete the arrangement so as to have a portable photometer for white light, a white ring surface, with an opening in it is provided on the outside of the sphere. The observer changes the angle of the sector until the hole in the ring becomes invisible, thus obtaining a measure of the light by which the white surface with the hole is illuminated.[70]

A novel method has been devised to measure the energy of the ultra-violet radiation emitted by a mercury arc lamp. This is based on the fact that the coefficient of velocity of hydrolysis of tetrchloroplatinic acid varies proportionately to the incident radiant energy.[71]

Investigators are still working on the application of photography to photometry and it is expected that an emulsion will be obtained which gives results comparable to the impression upon the eye. Means have now been developed for measuring intensities, opacities, and other properties which it is necessary to know of the developed emulsion, and the different materials possible to use in the emulsion have also been investigated.[72, 73, 74]

An instrument has been devised for observing intrinsic brilliancy. This consists of a lens equipped with a "cat's eye" diaphragm throwing an image of the source to be examined on a screen inside a blackened box. By means of a Lummer-Brodhun prism, the observer can compare the brightness of the image with that of a diffusing plate illuminated by a small standard incandescent lamp. The adjustment of equality of brightness is made by means of the diaphragm.[75]

Ophthalmology.

Many articles have appeared lately upon the requirements for hygienic lighting and the advantages of one system of lighting over another; these are largely, however, either recapitulations of previous knowledge or are inspired by the advocates of the method of illumination in question.

An investigation was made last year in regard to defects of vision among school children in Liverpool, from which it appeared that, as might be expected, vision was better among children attending schools in the outskirts where the open surroundings gave opportunity for open spaces than among those attending

[68] *Zeit. Instrumentenk.*, September, 1912.
[69] *Lighting Journal*, July, 1913.
[70] *Jnl. für Gasbel.*, July 12th, 1913.
[71] *Comptes rendus*, January 27th, 1913.
[72] *Le Genie Civil*, February 15th, 1913.
[73] *Comptes rendus*, February 3rd, 1913.
[74] *Elek. u. masch.*, May 25th, 1913.
[75] *Comptes rendus*, April 21st, 1913.

schools in the centre of the city. With one exception the girls' sight was distinctly worse than the boys', this being attributed by investigation to the fact that the girls' course included sewing. This was regarded as the most likely of any item in the school curriculum to affect the eyes, and is often carried out under the most disadvantageous conditions of lighting. One investigator thinks it would be desirable if sewing could be abolished altogether under the age of seven, and further urges that there is not enough discrimination during sewing lessons between children whose eyesight has been found satisfactory and those with serious defects.[76]

Similar investigations have been carried on in other countries. While it has been shown that conditions producing defective vision are now much more closely studied than heretofore, and that defective conditions are being remedied, the percentage of children suffering from poor sight is still large. Such subjects as size and style of type, quality and colour of paper, illustrations, angle, position of reading, and colour of blackboard and chalk have all been, and are still being, studied, particularly with reference to saving the sight of the children.[77]

A series of experiments was made to determine the perception of lights of short duration, the assistance of seventeen observers of different ages and occupations being enlisted. From the results obtained a curve was plotted showing the perceptibility of flashes of light in terms of durability and intensity.[78] Tests were also made by other experimenters along the same line.[79]

An interesting investigation was recently carried on by a French journal to find the combination of colours most legible at a distance. The order of merit is somewhat surprising, the best being black on yellow, while the customary combination of black on white appears sixth in a list of thirteen.[80]

A somewhat similar test was made to find, if possible, the most legible type to use for books and periodicals. The type proving best was the one selected by our newest illuminating engineering journal, while a rather startling conclusion was that the American typewriter stood in a class by itself as the worst.[81]

Two experimenters have recently published the outlines of recent researches lasting over a year upon the effects of radiation upon the eye, most of the tests being made upon rabbits. The light sources chiefly used were the quartz-tube mercury arc-lamp and the magnetic lamp. Much of the information obtained is not yet in shape for publication, but it was shown plainly that under the ordinary commercial conditions surrounding the use of even the more brilliant illuminating agencies, no specific danger exists; and that only by the grossest neglect and deliberate protracted exposure of the eye to the brilliant light sources at close range is there the slightest chance of injury to the organs of vision, except in so far as temporary injury may be due to the effect of ordinary visible radiation.[82]

Tests using commercial light sources and commercial colours were also made to determine the effect of a coloured background upon visual perception. The results were not fully reported, but they showed that the intensity of reflected light from an object is a much more important factor in perceptibility than colour.[83]

Investigation of the perception of colour shows that the duplicity theory can no longer be held, but that all facts harmonize with the theory that the rods are the organs which are concerned in the perception of colours of short wave lengths.[84]

It has frequently been said that with natural lighting out of doors, a higher intensity of illumination is necessary than with artificial lighting. A series of tests were made at sunrise and sunset on a number of observers, from which it was shown that daylight illumination in the open is satisfactory for reading at

[76] *Good Lighting*, September, 1912.
[77] *Ophthal. Record*, February, 1913.
[78] TRANSACTIONS Illuminating Engineering Society, November, 1912.
[79] *Electrical World*, August 9th, 1912.
[80] *Scientific American Supplement*, February 15th, 1913.
[81] *Lighting Journal*, January, 1913.
[82] *Electrical World*, May 24th, 1913.
[83] *General Electrical Review*, April, 1913.
[84] *Arch. of Ophtham.*, March, 1913.

all intensities as low as with artificial light, and probably lower.[85]

Illuminating Engineering Societies.

Since the last meeting of the Illuminating Engineering Society, another national illuminating engineering society has been formed:—the Deutsche Beleuchtungstechnische Gesellschaft. This is the third association of the sort in existence, these being in order of time of formation, the American, British and German. The first general meeting of the new society was held in the physical laboratory of the University of Berlin on Feb. 24th, 1913. Among the papers presented were: "The Eye and Illuminating Engineering," "Light Units," "The Boiling Temperature of Carbon in the Arc Lamp," "Method of Diminishing the Light Intensities in Photometry," "A New Method of Determining the True Temperature of Filaments in the Incandescent Lamp," and "The Present Disadvantages of the Sphere of Automobile Lighting."[86, 87, 88]

A gratifying announcement is that of the reorganization of the International Photometrical Commission. This was organised by the International Gas Congress in 1900, and held its first meeting in Zurich in 1903. This was composed of representatives with the co-operation of certain of the national laboratories. It is now proposed to extend the commission to include not only the gas interests but also the electrical interests, and to be representative of these industries, illuminating engineering societies and other associations interested in photometry and illumination and to be responsible to them. A sub-committee has already been appointed to consider photometerial units and standards.[89, 90]

The British Illuminating Engineering Society has partly completed a study of school and library lighting with a view to formulating recommendations suitable for general adoption. Committees of this society, in co-operation with committees of the Association of Teachers in Technical Institutions and the Library Association have issued preliminary reports on the artificial lighting of schools and libraries calling attention to a number of important features frequently overlooked, prominent among which is glare. Recommendations as to minimum illumination for various purposes were made.[91]

Relations of Illuminating Engineering to other Branches.

Illuminating engineering is gradually coming into recognition by other professions and arts. The architect is beginning to appreciate the value of a knowledge of the principles of illumination in decoration and utility, as is shown by the co-operation of the architect and illuminating engineer in planning the lighting features of the coming Panama-Pacific Exposition in San Francisco, and in designing the illumination of many important buildings, such as libraries, churches, restaurants, &c. At the International Congress of School Hygiene just held in Buffalo, two sessions were completely turned over to the Illuminating Engineering Society and presided over by a representative of that society. The theatres are also coming to the illuminating engineers for their scenic effects; and in one installation of especial interest, where the services of an illuminating engineer were enlisted, gauze scenery and dyes were used in preference to canvas and paint, and instead of using dipped lamps the effects were produced by colour screens. The lighting arrangement is such that the lighting of the scenery is entirely separate from that of the actors so that while the scenery passes through a very large range of colour changes, the colour of the light on the actors remains constant. Furthermore complementary spots are used to correct the colour of the actors' faces when coloured light has to be used on the stage proper. In this installation the use of the arc lamp has been entirely abandoned and the concentrated filament form of tungsten lamp used entirely. Footlights have been largely given up and the lighting

[85] *Electrical World*, July 5th, 1913.
[86] *Journal of Gas Lighting*, December 10th, 1912.
[87] *Electrical World*, April 26th, 1913.
[88] *Elek. Zeit.*, June 26th, 1913.
[89] *Journal of Gas Lighting*, December 17th, 1912.
[90] *American Gas Light Journal*, November 11th, 1912.
[91] *Electrician*, July 25th, 1913.

of the stage is arranged to produce natural effects by lighting from overhead by front lights in the gallery and by lights directed from one side of the stage so as to produce normal shadow effects. It is interesting to note that these changes reduced the maximum load from 45 to 5 kw.

Manufacturers are taking up the question of lighting their shops and mills, and have investigated the influence of the character of the light on the time taken to perform mechanical operations. One of our large lamp concerns recently sent a letter of inquiry to a number of industrial concerns; of the 209 replying, 164 said that improvements had been made in their lighting, and a large number of expressions of opinions were received to the effect that increased production, better goods, and greater satisfaction on the part of the workers had been the result. Moreover, in many cases the cost of lighting has been reduced.[92]

Merchants have been employing the illuminating engineer to such an extent that it is rare that a periodical devoted to the lighting industry does not contain a description of the lighting features of some large store in which the installation was carefully planned and well carried out. This applies also to most establishments depending for their success upon the general public.

That the work of the railway mail clerk is one of the most trying occupations as far as the eyes are concerned is now recognised, and the Post Office Department has issued specifications for lighting the mail cars, covering location of light source with regard to the initial illuminating values, absorption by globes and reflectors, light failures, emergency lighting, &c.[93] The data for these specifications were obtained from actual tests on a mail car of one of our large railroads.[94]

In this connection it may be well to mention that an exhaustive test has been made at the shops of one of our large railway systems to standardize the best method possible of train lighting. This test was made under the auspices of the Association of Railway Electrical Engineers.

The relation of lighting to the number of accidents has also been receiving attention as never before. The intensity of the illumination and the location of the sources have been studied in connection with moving machinery, passageways and stairs; and in this connection it has been suggested that too much light might be as bad as too little in the dazzling effect on the eyes. A very practical illustration of the relations of light to accidents is the statement of a leading casualty company of New York that "the greatest number of accidents occur during the months of diminished light." Furthermore, a prominent official of one of America's largest manufacturing companies is authority for the statement that "insufficient illumination" is frequently held by juries to be "contributory negligence," and in the defence of accident suits the lawyers of this company find it a valuable point to offer testimony by a competent witness to prove the adequacy of lighting arrangements in this company's plants.[95]

In this connection it may be said that several States have passed laws specifying the candle-power of locomotive headlights,[96] and a number of tests, the last under control of one of the State public utility commissions, were made to find out whether the lights complied with the law and also to determine whether the headlight might endanger the safety of operation of trains through interference with signal lights or in any other way. With electric headlights, numerous phantom lights were seen, but these were of the nature of mere flashes where the engine was running at the ordinary speed. There was difficulty in distinguishing classification lights and engine numbers on locomotives equipped with arc headlights, and precautions should be taken to place these marks at such a distance from the headlight that the latter may not materially interfere with their correct reading. The arc lamp should be switched off when passing through large yards and other places where it might have a tendency to interfere with the performing

[92] *Journal of Gas Lighting*, February 11th, 1913.
[93] *Lighting Journal*, February 11th, 1913.
[94] *Electrical World*, March 29th, 1913.
[95] *Safety*, p. 86.
[96] *Lighting Journal*, January, 1913.

of duty by yardmen or others, or to endanger their lives. An incandescent lamp should then be switched on.[97]

A report, rather startling in its novelty, has been issued to the effect that souring of milk is due to ultra-violet rays, and that milk may be kept sweet for days by putting it in a red glass bottle, or in a plain glass bottle wrapped in red paper.[98] A reverse action apparently on this order, and now creating much comment, is the use of ultra-violet rays for sterilising water, as noted above.

A suggestion is contained in an installation of gas arc lamps for lighting tennis courts. Perfect satisfaction was obtained, and the courts were even better patronised at night when it was cool than in the heat of the day.[99] This installation paralleled a similar one in another town in which tungsten lamps were used,[100], [101] and these, in turn, were followed by a golf putting course lighted by gas. The latest item of this sort is the equipment of a polo-field which is to be lighted by forty-eight 400-watt tungsten lamps with metal reflectors, the installation being designed to give one foot-candle on the horizontal plane.[102]

[97] *Scientific American Supplement*, February 1st, 1913.
[98] *Scientific American*, June 7th, 1913.
[99] *Good Lighting*, September, 1912.
[100] *Electrical World*, July 12th, 1913.
[101] *Electrical World*, August 24th, 1913.
[102] *Lighting Journal*, May, 1913.

(*To be continued.*)

AN ENTERPRISING LIGHTING EXHIBIT IN NEW YORK.

By A Correspondent.

An interesting demonstration of good and bad methods of illumination was carried out by the American Illuminating Engineering Society at the International Exposition of Safety and Sanitation in the Grand Central Palace, New York, during December 11th—20th, 1913.

The exhibit took the form of a series of eight booths, each devoted to some specific branch of lighting and illustrating the fundamental rules of good illumination.

It is stated that the display attracted a very considerable amount of attention. To many people it was a revelation to find that good illumination, besides being intimately connected with industrial safety, also plays an important rôle in artistic and architectural matters.

At the conclusion of the Exposition the entire exhibit was removed and placed in the American Museum of Safety where it will form a permanent educational feature.

The following is a reproduction of the actual programme describing the exhibit:—

Booth No. 1—Artificial Daylight:

This booth is illuminated with artificial light corresponding in colour to average daylight. It is used for matching and selecting coloured material, precious stones, etc.

The correct colour is obtained in this case by passing the light through coloured

glass, which absorbs part of the colours that are in excess in the original light.

Booth No. 2—Glare :

The purpose of this booth is to show the effect of glare from glazed paper on the ability of the eye to see. Note that one-half of the card has a glazed surface from which the light directed upon it is reflected. The other half of the card has a matt surface like that of blotting paper. The beams of light which fall upon it are broken up and reflected in many directions (diffused). As the card oscillates you will note that in all positions the letter " E " on the matt surface is always clearly visible to the eye. This is not the case with the glazed half of the card. The letter " E " is visible in certain positions and cannot be seen in others.

This demonstration shows clearly why it is difficult to read certain of our books and magazines which are printed on glazed surfaces. The preservation of your eyesight demands that your reading matter be printed on unglazed paper. Insist on it.

Booth No. 3—School Room Lighting :

This miniature room is equipped with blackboards such as are used in school rooms, while the model in the centre represents a student reading. The changes represent the lighting effects obtained with window light from different directions, and also from a good artificial lighting system.

The following are some of the interesting observations to be made :

A. For reading a book in the hands or on the desk, light should come from the side or rear in such a direction as to avoid glare in the eyes and shadows on the book.

Note effect of side and rear windows in illuminating the book.

B. Blackboards between wndows are not easily seen, because they are not strongly illuminated, while the adjacent windows tend to blind the eyes with glare.

Note how much more easily the rear blackboards may be read when lighted from the side window.

C. Dull surface blackboards are more comfortable to look at and more easily read than glossy ones. When viewed from certain angles in which light is reflected it is impossible to read matter on glossy blackboards, while the effect may cause serious eyestrain.

Booth No. 4 :

This booth is a demonstration of correct and incorrect methods of lighting show windows. The correct method here illustrated consists of light sources completely hidden from view by a reflector which directs the light from in front and downward over the display, thus illuminating the goods with a high intensity of light and at the same time protecting the eyes of the observer. These points are essential in a well-lighted window since the object of the illumination is to display the goods attractively and not advertise the lighting apparatus.

With the incorrect method, you will note that bright light sources are placed between the goods on display and the observer. The result is the observer is partially blinded by the brilliant lights and thus prevented from seeing the goods advantageously. Moreover the light sources being the prominent features of the window attract the major attention rather than the articles displayed.

From the hygienic standpoint, this latter method is atrocious, inasmuch as it exposes the eye to glaring light sources.

It will be noted that part of the display is in shadow, which is still further objectionable.

Booth No. 5—Factory Lighting:

This exhibit illustrates correct methods of machine lighting by :

(1) Localised lighting, (2) general (or localised general) lighting, (3) by a combination of both.

The lamps are equipped with reflectors which distribute the light economically in useful directions, and protect the eyes from the brilliant light sources.

The lighting units are located so as to give the highest intensity on the most important parts of the machine and eliminate objectionable shadows.

The intensities required would depend upon the fineness of the work.

Note that the light finish of room and machinery economise light, and make the parts more readily visible. Good illumination preserves eyesight and reduces liability to accident.

Booth No. 6—Factory Lighting—Poor :

This exhibit, in contrast to Booth No. 5, calls attention to some common defects in factory lighting.

(a) Glare—The bright light shining in the workman's eyes interferes with his seeing ; impairs his eyesight : causes

headache, etc., and increases liability to accident.

(b) Wrong Direction of Light—The wrong position of lamp places important parts of machine in shadow, while adjacent lighted parts make them seem darker by contrast. These conditions cause eyestrain.

(c) Poor Distribution—If the lamp were correctly located and equipped with proper reflector, that part of the light which is now worse than wasted could be utilised, thus obtaining more economical illumination and protecting the eyes of the workman.

(d) Dark Surfaces—The dark walls and machinery not only absorb considerable of the light but produce mental depression and impair the ability to see form and detail.

Booth No. 7—Examples of Four Methods of Room Lighting in Common Use :

(a) Bare Lamps. Note glare and lack of diffusion.

(b) Lamp with opal glass reflector. An example of direct lighting.

(c) Lamp with opal glass reflector inverted so that the major portion of light is thrown on ceiling for redistribution. An example of semi-indirect lighting.

(d) Lamp with opaque reflector beneath. All light is thrown on ceiling and upper walls for redistribution. An example of indirect lighting.

The bare lamp represents poor lighting practice ; it produces glare, sharp shadows and inefficient distribution of light.

The other three methods are considered good practice; the selection depends upon the type and finish of room, the use to which the light is to be put and often upon personal taste.

Booth No. 8—Direction of Light :

This exhibit illustrates the remarkable difference in the appearance of objects lighted from particular directions. The model is lighted from above, the right, below, the left, and finally by more diffused light from above on the right.

Not only are statuary and architectural forms affected in appearance by the direction of light, but all ordinary objects are more or less affected.

This extreme case illustrates the importance of proper direction of illumination in showing the beauty and truth of form.

ILLUMINATION OF RAILWAY CARRIAGES.

A recent number of the *Electric Railway Journal* contains an account of some experiments made during 1911 and 1912 by the Cleveland Railway (U.S.A.) on the lighting of the carriages.

A considerable number of tests with carbon and metallic filaments have been made, and it now appears established that the latter can be quite successfully used for railway carriage lighting. The following table gives a synopsis of the results on two cars experimented with :—

The comparative efficiency of illumination of the various systems works out as follows :—

64-watt carbon lamps .. 100 per cent.
23-watt mazda lamps .. 307 per cent.
100-watt mazda lamps .. 417 per cent.

It is interesting to note that the tendency in modern carriage lighting appears to be towards using a few large and well-shaded units instead of rows of small unscreened units, which are apt to have a distinctly glaring effect.

	Total watts.	Watts per sq. ft.	Average ft.-candles.	Ft.-candles per watt per sq. ft.
Car No. 537—				
100-watt lamps ..	364·5	1·365	3·31	2·42
Car No. 510—				
23-watt mazda ..	377·5	1·415	2·52	1·78
64-watt carbon ..	1063·0	3·980	2·30	0·58

THE LIGHTING OF A SYNAGOGUE.

From time to time reference has been made to the subject of church lighting in the columns of the ILLUMINATING ENGINEER, and in January, 1909, a special section was published dealing with the subject. It may be noted that a paper on the subject was read at the recent convention of the American Illuminating Engineering Society, to which we made reference in a recent issue.

The lighting of a church provides scope for quite an exceptional amount of tact and discrimination. There are always special circumstances to be considered, and it is only rarely that the consulting engineer can arrange things as he would like to have them from the purely "illuminating engineering" standpoint. In addition there is, in the case of old buildings, a natural disinclination to introduce new illuminants. For example, when some years ago it was decided to redecorate the Bevis Marks Synagogue in London, the question of the lighting came up for consideration. But it was decided to retain the original Dutch fittings equipped with candles, which are modelled exactly on the originals in the famous synagogue in Amsterdam. There is a certain symbolism in the use of candles and oil lamps; in past ages they formed the only practicable method of illumination in churches, and often played an integral part of the worship. The burning of a candle, for example, has a certain significance as illustrating human life. It burns steadily for a while and then dies down, and while burning it has a certain flickering and varying tendency which is suggestive of a living thing, and symbolises the vicissitudes of human life. The steady shine of electric light, on the other hand, has no such significance, and its abrupt extinction through the blowing of a fuse is only suggestive of a tragically sudden death.

FIG. 1.—A view of the Synagogue, taken from the back gallery, looking towards the side. Note the illuminated text in the background.

(Photo taken entirely by artificial light.)

In this article an account will be given of the lighting of a large synagogue. The building and fixtures are in Oriental style, the interior being lighted by gilt dome fittings of pierced metal similar to those often met with in the East.

Fittings of this kind were originally used with oil lamps, but in this synagogue electric metal filament lamps were installed some time ago. Quite recently it was decided to redecorate the synagogue, and the opportunity was taken to improve the illumination. The conditions were unsatisfactory in several respects. The illumination on the sliding racks, where books are placed during the service, was insufficient for reading in many cases, especially in the case of seats at the back. It was also complained that the lights on some of the large chandeliers fell right in the line of vision of worshippers, causing a decidedly wearisome effect.

On the other hand, it was resolved that no changes should be made which would not be in harmony with the existing style of decoration, and that the original fittings, which were valued as gifts from prominent members of the community, should be retained. The circumstances did not provide for much alteration in the position of lights, and it was desirable to use the existing points as far as possible.

In order to improve the illumination it was therefore found necessary to add a number of new fittings which were executed in exactly the same style as the originals. The lights were thus spaced at more frequent intervals, giving a more uniform illumination. The positions of the large chandeliers were also altered, the central chandelier being removed to a new site in the back gallery for which its dimensions and style were more suitable, and the chandelier originally over the gallery was transferred to the middle of the building. In addition, the chandeliers were suspended considerably higher up so as to be well out of the line of vision of the worshippers.

In order to improve the distribution of light and avoid the glare from bare filaments Holophane hemispheres were fitted to the larger fittings and suitable pines on the smaller ones. On each of the chandeliers a very large central Holophane hemisphere, surrounded by a number of hanging pines, was used.

It may be added that all these fittings are arranged in a very accessible manner so that the pines and hemispheres can be very conveniently displaced when it is desired to insert a new lamp, or for cleaning; also the fact of only two different units (hemispheres and pines) being used makes it easy to interchange any glassware at any time should this be necessary. The chandeliers can be lowered on winches. One other point that came up for consideration was the desirability of using a three-light fitting in the hemispheres. From one point of view this is advantageous, since if one lamp goes the other two will still be burning and the fitting would not be completely extinguished. But it was pointed out that, for this very reason, the replacing of lamps might be neglected; and that nothing looks worse than a series of fittings some of which are much brighter than others. Consequently it was decided to utilise a single 100-watt lamp.

The nature of the present arrangement will be understood from the illustrations. The seats under the galleries are lighted by fittings carrying 50-watt metal filament lamps and Holophane pines; there are 14 of these under each gallery. For side gallery light 100-watt metal filament lamps in Holophane hemispheres are provided. The lighting of the central part of the floor comes mainly from the large chandelier carrying a hemisphere and a series of 15 pines. The back gallery is at present lighted by one large chandelier carrying a hemisphere and 12 pines, and by two fittings at the back similar to those in the side galleries; it is probable that the illumination will be strengthened still further by adding two more of these fittings over this front portion of the gallery. A special feature on the floor is the lighting of the desk (from which the law is expounded) by two pines mounted on brackets and two reflector bowls on standards. The former also serve to give light to the important seats immediately below this desk, where the wardens of the synagogue sit.

These features are also illustrated from the photographs reproduced in Figs. 1 and 2, which were taken from the gallery. These show another interesting point in the design—the use of concealed lamps in reflectors to illuminate the text under the arch.

As a result of these changes the lighting has been much improved. The general effect is now cheerful as is desirable in a place of worship, but is no longer glaring.

The moderate intrinsic brilliancy of the glassware does not prevent the eye from taking in the metal work features, and in the smaller units allows sufficient light to pass upwards to illuminate the interior of the pierced domes, producing a very charming effect. In the case of the large chandeliers it was found desirable to add one or two lamps inside so as to illuminate the interior and show up the metal apertures in strong relief. In addition, with the present illumination the decorative

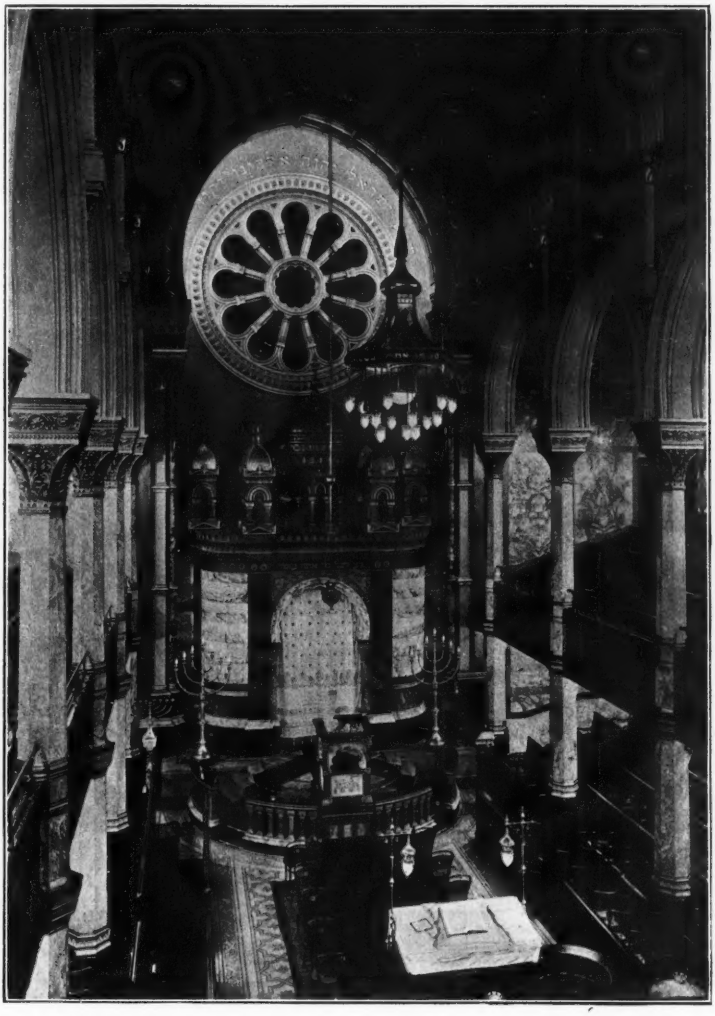

FIG. 2.—A general view, showing part of the floor of Synagogue, the central chandelier, and the illuminated text at the back. In the background will also be seen standards carrying seven candles, and the hanging oil lamp, kept continuously burning.

(*Photo. taken at* 10 *o'clock at night entirely by artificial light.*)

style of the building is shown off to much better advantage than before, and there is plenty of light allowed for the walls and ceilings. The illumination on the desks has also been considerably improved. Before the change was made there were some desks which received less than half a foot-candle, and some seats at the back on which the illumination was almost too low to measure. At present the illumination over practically the whole of the church has been brought up to about a foot-candle, and in some of the most important seats exceeds over 2 foot-candles. A good reading illumination is most essential in a synagogue.

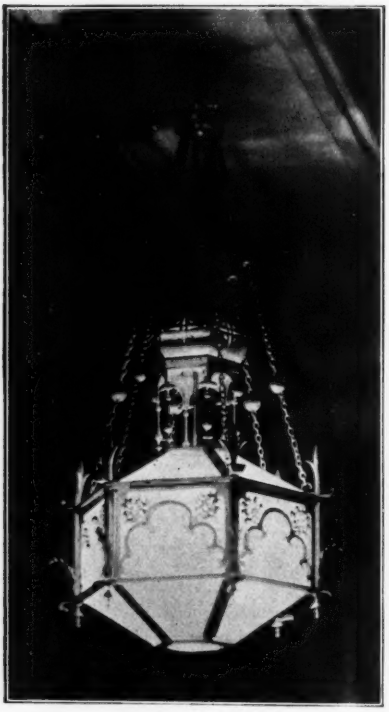

FIG. 3.—Special fitting used to illuminate the entrance hall. Cluster of lamps surrounded by diffusing glass; metalwork of oriental design.

Improvement has also been made in the lighting of the corridors, stairs, and landings, where a combination of Holophane bowl reflectors have been largely employed; bowls and spheres were installed in the committee room. Fig. 3 shows the redesigned fittings used in the entrance hall which contains a series of tungsten lamps surrounded by diffusing glass. Outside the synagogue there are two fittings, one on either side of the steps, each containing 100-watt tungsten lamps in a Holophane hemisphere similar to those used in the upper gallery within the synagogue. These serve to draw attention to the building, and are lighted up while the service is going on.

The general scheme of lighting, which constitutes a considerable improvement, affords an interesting example of the compromise that has usually to be considered in church lighting.

ELECTRIC TORCHES FOR THE POLICE.

IN view of the proposal that the police of the Metropolis should be furnished with electric torches for night use, in place of the old-fashioned oil lanterns, it is interesting to note that some little time back the Port of London Authority made arrangements to equip its police force with an electrical illuminant. The Authority have lately accepted a tender for the supply of an estimated quantity of 600 dozen dry batteries for the electric torches adopted for the dock police. The torches are found to work satisfactorily, and are considered to be much safer than the lamps which they superseded.—*Westminster Gazette*, Jan. 13th.

HALF-WATT LAMPS IN A LONDON STORE.

WHILE so much is being said about the possibilities of the new half-watt lamps it is interesting to notice that there is one place in London where quite a number of these lamps have been installed and have been in operation for some time.

The photograph shows a picture of Harrods' Stores (Brompton Road, W.), where the end three rooms are lighted by about fifty 1000-c.p. lamps in diffusing glass globes. The consumption in these rooms is stated to be about 2 watts per square foot. The illumination is naturally very bright, values of 8-16 ft.-c. at a height of about 3 ft. from the floor being measured on the occasion of our visit. The light yielded by the new lamps is distinctly whiter than that of the ordinary tungsten lamps consuming about 1·2 watts per candle. In walking from the rooms lighted on the old style into those lighted with the ½-watt lamps, the difference both in colour and brightness was quite evident, the delicate shades of silk, &c., being chiefly affected.

It seems probable that the introduction of these lamps will lead to a general rise in the standard of illumination in large stores where "display-lighting" is aimed at, and their general use will raise entirely new problems in illumination.

SCHOOL LIGHTING.

By E. H. T. Nash, D.P.H., Medical Officer to the Borough of Wimbledon.*

In the first part of this paper Dr. Nash summarises the early work of Cohn and others on School Lighting, and refers to the regulations in various countries connecting the window space and floor area. The French authorities claim that good natural lighting can only be obtained with a ratio of window space to floor area as low as 1-3, 1-2, or even 1-1·5. In America there are schools where the window space is actually greater than the floor area.

Dr. Nash is a strong advocate of left lateral lighting. Bilateral lighting almost always gives rise to inconvenient shadows and is only permissible when the windows on the right are comparatively small and high up. One advantage of such windows, however, is that a through draught is readily produced, so that the method is conducive to good ventilation.

In general, windows in parts of the room other than the left wall are also rather objectionable; but there is good reason to suppose *overhead* lighting when available is one of the best methods of all.

In England the average height of the schoolroom varies from 12-14 ft., and the Board of Education specify that in a room 14 ft. high the measurement from the window to the most remote wall should not exceed 24 ft. 8 in. Of late special efforts have been made to secure a maximum of window area by carrying windows as far as possible up towards the roof. Cast-iron mullions have been substituted for brick in the United States. This also diminishes the solid obstruction in the window area. More recently the idea has been carried into effect in one of the large schools in Wales as illustrated by Sir Geo. Newman in one of his recent Chadwick lectures. The essential idea in all such cases is to take advantage of light from the upper part of the windows. As a rule the illumination derived from the lower part of the window is, relatively, of small value.

A very debatable point is the use of supplementary windows on the inside walls of the schoolroom opening into the main hall. It would seem preferable to have light-coloured opaque walls which reflect the light well, and to see into the adjacent room is apt to be distracting. It was formerly considered that these supplementary windows facilitated supervision by the head teacher. But it is questionable whether, even from this standpoint, they are of great value. The value of light-tinted wall-surfaces, such as reflect the light and improve the illumination on the seats most remote from the window, is fully recognised.

In the latter section of his paper Dr. Nash refers chiefly to artificial lighting, summarising the conclusions embodied in the recent preliminary report by the Joint Committee of the Illuminating Engineering Society.

Dr. Nash emphasises the value of polar curves and spacing rules for lamps which greatly simplifies the problem of predetermining the illumination in a room. Recently the gas lighting in one of the schools in Wimbledon was improved under Nash's supervision and a minimum of 3·5 foot-candles was specified and complied with. In these schoolrooms an approximation to the left-lateral lighting derived from daylight was obtained by using three rows of lights, displaced somewhat towards the left: in this way the probability of inconvenient hand shadows being caused by light coming from the right was diminished. This, Dr. Nash believes, is one of the first instances in the kingdom of gas lighting being carried out under the supervision of the Medical Officer according to a definite scientific formula. It was striking to note that by replacing the original flat flame burners it was possible to get eight times the light at about the same cost as before.

In the discussion that followed, Dr. J. Kerr, Dr. Bishop Harman and others spoke, and Mr. J. S. Dow, on behalf of the Illuminating Engineering Society, expressed the hope that some of those present would come to the meeting and join in the discussion of Mr. Waldram's forthcoming paper.

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* Abstract of a paper read at the Medical Officers of Schools Association, Nov. 28th, 1913.

TRANSACTIONS
OF
The Illuminating Engineering Society
(FOUNDED IN LONDON, 1909.)

(The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.)

SOME PROBLEMS IN DAYLIGHT ILLUMINATION.

[Meeting held at the House of the Royal Society of Arts (London), at 8 p.m. on Thursday, Jan. 15th, 1914.]

THE last meeting of the Society took place, as announced above, on Jan. 15th, Dr. James Kerr being in the chair.

The minutes of the last meeting having been taken as read the Hon. Secretary announced the names of new members in the usual way.

THE CHAIRMAN, in opening the proceedings, recalled that at the last meeting it had been found impossible to deal adequately with Mr. Waldram's paper in the time available, and the discussion was therefore adjourned. But before reopening, he understood that Mr. Waldram had some supplementary matter to bring before the meeting and he would accordingly call on him to present this information first.

MR. P. J. WALDRAM then presented several diagrams illustrating additional tests of daylight illumination, with special reference to small models (see p. 77).

The Chairman then called upon Mr. A. P. TROTTER to open the discussion, in which PROF. W. C. CLINTON, MR. H. L. DUNSTALL, MR. C. C. PATERSON, MR. W. H. WEBB, MR. P. L. MARKS, MR. V. H. MACKINNEY, DR. F. GANS, and MR. L. GASTER took part. Subsequently MR. J. S. DOW read some written communications received from MR. T. S. RITCHIE, MR. EDWARD WARREN, PROF. F. K. RICHTMYER (Cornell University, U.S.A.), and PROF. MAX GRUBER (Munich).

In conclusion Mr. P. J. Waldram briefly replied to the various points raised, and a very cordial vote of thanks was moved to him for his very interesting and able paper.

THE CHAIRMAN announced in conclusion that the next meeting would take place on Tuesday, Feb. 17th, when Professor Thompson would open a discussion on the Lighting of Art Studios and Picture Galleries. The meeting then terminated.

NEW MEMBERS OF THE SOCIETY.

THE names of the applicants for membership, read out at the previous meeting on December 16th,* have now been formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society. In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon Secretary at the meeting of the Society on January 15th :—

Brinckman, M.	Manager, Messrs. E. M. Brinckman & Co., 99, Redcross Street, Southwark, LONDON.
Laurence,	Gas Engineer, Commercial Gas Co., Stepney, LONDON.
Parrish, H. F.	Engineering Dept., Holophane Ltd., 121, Bushey Hill, Camberwell, LONDON.
Thorne Baker, T., *F.C.S.*	Technical Expert, Farleigh Lodge, Warham Road, Croydon.
Thornley, J. W.	Asst. in Outdoor Dept. of Salford Corporation Gas Works, 477, Liverpool Street, Sudley, SALFORD.
Watkinson, J. G.	Proprietor of J. & W. B. Smith, 15-23, Farringdon Road, LONDON, E.C.

* *Illum. Eng. Lond.*, Jan., 1914, p. 14.

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909.)

OFFICIAL ANNOUNCEMENTS.

The next Meeting will be held in the House of the Royal Society of Arts, 18, John Street, Adelphi, London, at 8 p.m., on Tuesday, February 17th, 1914.

At this Meeting a discussion on "The Lighting of Studios and Art Galleries" will be opened by Professor Silvanus P. Thompson.

Tickets can be had on application to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.).

Annual Dinner, Friday, February 13th, 1914.

The Council have decided to hold the **Annual Dinner** during the present year on **Friday, February 13th.** It is earnestly hoped that Members will make a special effort to be present on this occasion, and that they will bring with them, as guests, several friends, whose sympathy and support would be of value to the Society.

The Dinner will be held at the **TROCADERO RESTAURANT,** Piccadilly, London, W., and the price of Tickets will be **10s. 6d.** (exclusive of wine).

APPLICATIONS FOR TICKETS should be addressed to the **Hon. Secretary, Mr. L. GASTER, 32, Victoria Street, London, S.W.,** preferably not later than Friday, February 6th.

THE LIGHTING OF LONDON.

A paper on the above subject will be read before **The London Society,** on **February 10th,** by **Mr. Leon Gaster** (Hon. Secretary of the Illuminating Engineering Society). The meeting will take place at 8 p.m., in the Hall of the United Service Institution (Whitehall, London, S.W.).

This paper, which will be fully illustrated by Lantern Slides, will trace the lighting of London from its early stages up to the present day, and will deal in a popular manner with some modern problems in public lighting.

We are asked by The London Society to state that a special invitation is issued to members of the Illuminating Engineering Society to be present. Further particulars can be obtained from the Secretary, **Mr. P. W. Lovell, 27, Abingdon Street, Westminster, S.W.**

SOME PROBLEMS IN DAYLIGHT ILLUMINATION.

WITH SPECIAL REFERENCE TO SCHOOL PLANNING.

Discussion, Dec. 16th, 1913, and Jan. 15th, 1914.

Discussion of Paper read by Mr. P. J. Waldram at the Meeting of Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m. on Tuesday, December 16th, 1913.

AT the conclusion of Mr. P. J. Waldram's paper read on Dec. 16th, 1913, THE CHAIRMAN (Dr. James Kerr) made a few introductory remarks. He expressed the indebtedness of the meeting to the author for the exhaustive way in which he had summarised the intricate problems facing those who have to deal with the subject of daylight illumination. There were, he said, very great difficulties in carrying out tests of daylight illumination in an accurate and scientific fashion, although, at the same time, it was comparatively easy to do so in a kind of general and rough way. When he first began to look into the lighting of schools twenty years ago he contented himself with a row of millimetre dots. If these were distinguishable by the existing illumination at a distance of 20 ft., a place was considered suitably lighted for working. But although that was a simple and practical method, it had nothing like the accuracy required when one desired to tackle a scientific problem.

There was an enormous amount of material in the paper, and it would be impossible to get through an adequate discussion of this in the one evening. It had been suggested that as a large number of communications had been received from abroad, and a great deal of other matter had been prepared, which would be published in the Journal, it would be convenient that the main part of the discussion should be postponed until the next meeting, when all this material would have been before the members.

He proposed shortly to ask Mr. Dow to give a short resumé of the communications received from some Continental authorities, and meanwhile would just refer to past work on the subject, some of which had been summarised in the appendix to Mr. Waldram's paper. All these researches showed that, whereas it was comparatively easy to agree on a definite standard for artificial lighting, this was extremely difficult to define for daylight. The difficulty arose from the adaptation of the eye, which did not vary greatly with artificial lighting, but with daylighting might vary twenty times or more in its sensibility. Working on objects in a poorly lighted corner of a room with the eye adapted for the general daylight of the rest of the room might result in the objects being very badly seen, although perhaps more strongly lighted than would appear brilliant to the eye by artificial light.

MR. J. S. DOW then gave a brief summary of the replies so far received to the list of queries. (See pp. 34-43 in last number.)

MR. F. R. FARROW (F.R.I.B.A.) expressed his interest in the paper which had been read by Mr. Waldram, and the replies which Mr. Dow had summarised from abroad. He would like to propose a vote of thanks to Mr. Waldram for bringing the matter forward. The first step towards knowledge was to become aware of what we do not know, and that Mr. Waldram had certainly put before them in very clear and unmistakable language. The difficulties with regard to an estimation of the various points relating to daylight illumination were so great that it seemed to him that, in order to arrive at any practical data of value for practical use, we should have to eliminate a good deal of what we might bring into our calculations. The author had referred to the fact, with which everybody was well acquainted, that our eyes are very bad instruments for the estimation of the degree of the value of light, but he was not prepared

to follow Mr. Waldram in his suggestion that that was due to hereditary causes. It was due, he thought, rather to the provision which Nature makes, by which we do not make use of all the light that is given to us in daylight. The contraction of the pupils of the eyes cuts off what light we do not want, therefore it was impossible to make use of the eye as an instrument for measuring the degree of light. Consequently it seemed to him that we might very well omit all considerations of the higher powers of daylight illumination, and confine our attention rather to a consideration of what is the minimum desirable and necessary for ordinary use. He was pleased to hear of the questions which had been put to the foreign members, and welcomed this method of obtaining advice. Speaking as a practising architect, he could say that the members of the R.I.B.A. wished to be told the degree of illumination which scientific men and doctors regarded as necessary for the health of the eyes as well as for practical use. When they received that information architects could begin to consider how that degree of illumination could be best provided. He was particularly interested in the question of the value of the light from various parts of the external hemisphere. Probably they would find that the value of lateral light would follow the law which was now generally adopted with regard to the value of vertical degrees, namely, that the cosine determines the value of various angles in vertical light, and he believed that the lateral would be found to follow the same law. In this way a calculation, based on a knowledge of what area of the hemisphere was open to any particular window, would show exactly what proportion of the whole available light might be got through that window. The value of it, of course, for lighting purposes was affected by the remarkable variation in the intensity of daylight during different parts of the day, as had been emphasised in the paper. He could speak on behalf of the whole of the Royal Institute of British Architects in thanking the Society and Mr. Waldram in particular for the study they had given to the various problems relating to illumination. The results of this study would be of extreme value to architects, who were expected to know something about multifarious things, and he sincerely hoped that the Society would continue to prosper more than ever in the future.

DR. E. H. T. NASH (Medical Officers of Schools' Association) said that his point of view was necessarily limited in that he had to speak with regard to schools but he did not think that sufficient attention had been paid in the past to the effect of lighting in the design of a school. It was in this respect that the Illuminating Engineering Society was doing good work, and when this work was completed something would have been done which would confirm or otherwise the attitude which the Board of Education took up with regard to the size and shape of classrooms in schools. It seemed to him, speaking from the point of view of a school medical officer, that they must first evolve the ideal classroom, and around that construct the school. Unfortunately the majority of architects constructed their schools largely with regard to the amenities in other directions, and the schoolroom came almost as an afterthought. After all, however, the children were spending the bulk of their time in the schoolroom, and the first consideration should be, what is the ideal classroom? Although it had not been sufficiently considered, daylight illumination, like artificial illumination, was largely a matter of cost. The daylight obtained in a room depended upon the height of the window head, and the French authorities in 1882 had laid down definite regulations with regard to this. The extra height of the window head meant an extra amount of cubic contents of the building, so that daylight lighting was to a large extent relative to the amount one was prepared to spend on the building.

Unfortunately, this matter of lighting had only recently been taken up, and school medical officers felt that their thanks were mostly due to those men who had taken quite a new line. He spoke particularly of Mr. Kirby, of Bradford, and Mr. Widdows, of Derby, whose designs had hitherto been looked upon as freak designs, but these architects had set out to solve some of the

problems which school medical officers met with day by day. The question of the design of classrooms must depend to a large extent on what light was intended and required. If insufficient light was being obtained—and that was what medical officers believed to be the case, particularly in the winter months—then it was a question as to what alteration should be made in the shape of the classroom, and the position and size of the windows. The Board of Education had laid it down that the square classroom was the best, and that was generally adopted in English schools, but almost all Continental schools were of rectangular shape, the majority having three rows of desks, whereas in the English schools there were four rows of desks, and sometimes five. That meant a considerable difference in the shape of the classroom, and also in the shape of the building. These considerations arose out of the question as to what was the best source of lighting.

The majority of authorities regarded left-lateral lighting as the best, and he personally endorsed that, but they were face to face with certain other opinions, notably on the part of some continental authorities, and Dr. Combe, a school medical officer, although he was opposed to bilateral lighting, was in favour of lateral lighting with high back lighting. That also was the prevalent opinion in regard to American schools, and a very large number of schools had been built in America with left lateral lighting and high back light. Dr. James Kerr, however, pointed out some years ago the extreme gravity of this back light; as sufficient back light gives a shadow, with the result that the children, in order to dodge their own shadows, were distorting their spines. It would have to be found out whether this was so or not, and whether windows placed high up could be utilised with advantageous effect. Although bilateral lighting had been spoken of in the paper, nothing had been said about differential bilateral lighting. It was suggested in France some years ago that the difficulty of bilateral lighting might be got over by using frosted glass on the right-hand side so as to get a diffused light. It might be possible to use a certain amount of this high up, because on the right-hand side under the window there were no shadows, and the light from that window only impinged on the part of the room nearest the main light, when it would be practically obliterated by the light falling from the left window.

Another point was as to the best proportion of window area to floor area. For classrooms the Germans preferred 1 to 4 or 1 to 6; we in Great Britain preferred 1 to 5, whilst some French authorities worked on the basis of 1 to 3 or 1 to 2 or even 1 to 5. At the Franklin School, Washington, the actual surface of the window area was greater than the floor area, and the whole difficulty was to decide what was the right proportion to use. The majority of schools had heavy mullions, and particularly so was this in the case of the old church schools. In America Warren Briggs had substituted cast iron mullions for brick, and Mr. Kirby had done away with them altogether in the Undercliffe School at Bradford, the windows occupying the whole width of the outer wall. These were all matters which would have to be taken into consideration, but so far very few architects had really faced the problem. The idea had been carried out recently in one open-air school, in which the windows were made so that the whole frame rolled back like a folding partition, leaving the whole window expanse open to the air. These problems were ones which particularly interested the school medical officer, who, however, must look to the architect for assistance. In the past, however, the architect had given the school medical officer very little assistance in these matters. There were a few exceptions, and in this connection he might refer to a paper before the Royal Sanitary Institute, by Mr. W. H. Webb. The architects rather seemed to regard the school medical officer as a sort of weird person who had no real *locus standi* in the matter. After all, however, the school medical officers were the people who worked in the buildings day in and day out, and they naturally saw results which the architect did not see. The architect, as a rule, had not much concern with the school once it was built and his account settled.

It was not sufficiently recognised how the lighting value could be added to by a reflecting wall on the side away from the window. Some measurements made in one of his own schools showed that in one room in which there was a borrowed light from a central hall there were 4 foot-candles on the desks, whereas in the next room with a reflecting wall, the illumination was 5·5 foot-candles. The schools which Mr. Widdows was now designing were an endeavour to solve some of these problems, and although he admired this effort, he did not think Mr. Widdows had succeeded yet. The bilateral lighting adopted by him he regarded as absolutely bad. Left lateral lighting was the ideal which architects would have to attain, and the point which came in was what shape of room would give that lighting. Personally he did not think that a square room was going to do it, in spite of the fact that the Board of Education had laid this down, as it had been laid down. That with the usual height of window it was impossible to efficiently light a desk more than 18 feet from the window. The work which the Illuminating Engineering Society was now doing might have a very important effect upon the architecture of schools in the future if the figures now being obtained proved to be right.

Dr. Nash concluded by showing lantern slides of a number of schools in different parts of the world, and describing their characteristics.

Resumed Discussion :—

The discussion being resumed on Thursday, January 15th, THE CHAIRMAN (Dr. James Kerr) called upon Mr. P. J. Waldram to add a few supplementary remarks on his paper.

Mr. P. J. WALDRAM then presented some notes showing the difference between the real and the apparent amount of light enjoyed at a reasonably well-lit situation and upon the accuracy with which measurements of the light in rooms correspond to those taken simultaneously in exact models with the surroundings exactly reproduced.

To illustrate the first point, Mr. Waldram took the case of the average worst desk in a standard elementary school class-room, which he described as a position comparable with the middle of an ordinary room, and receiving on grey days 1 per cent. of the light falling on the sill with a free horizon, or $\frac{1}{2}$ per cent. of that falling upon a card on the roof. He then took 1 foot-candle as the mean illumination required for ordinary purposes, pointing out that he had noticed that his draughtsmen habitually failed to light up until the daylight illumination on their boards fell to about one-third of a foot-candle, whilst he personally did so at about one-fourth to one-fifth of a foot-candle.

The average curves in Fig. 8 were then set up from all available data upon the diurnal and yearly variation of daylight including Dr. Basquin's observations in Chicago and Mr. Waldram's in London ; and the effect of a 10 per cent. loss of such total light available was also shown. Mr. Waldram proceeded to explain that daylight was tidal with long high tides in summer and short low tides in winter. In the same way that a boat drawing 15 in. will float as easily in 18 in. of water in a creek as in an estuary 18 ft. deep or in the open sea, so also will the eye take the 1 foot-candle, which is the apparent limit of its requirements in diffused daylight, as readily from the back of a room enjoying 2 foot-candles as from the front of the same room where 20 foot-candles are available or outdoors where the light may be 800 foot-candles, and it is no more conscious of the actual amount of light it is drawing from than a boat is of the depth of water in which it floats, because the iris diaphragm automatically keeps the necessary "draught" of the eye at about 1 foot-candle.

Mr. Waldram also described a long and stringent series of tests recently carried out by Prof. Clinton and himself at University College to ascertain whether observations of the light at 18 points

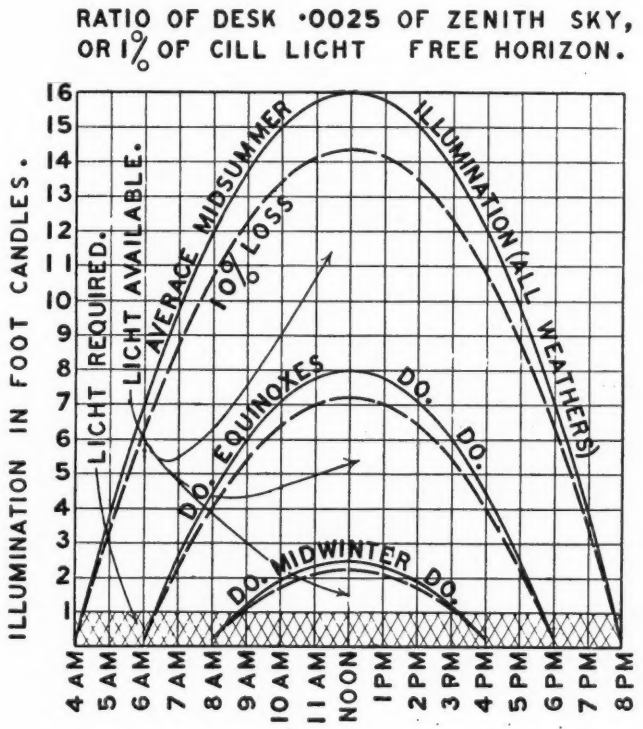


FIG. 8.

in a large laboratory comprising seven windows of different character, aspect and direction, corresponded with simultaneous observations at similar positions in a scale model of the laboratory and its surroundings placed on the roof. After describing the earlier difficulties due to the fact that the instruments used proved to be sufficiently delicate to be affected by small inaccuracies in the exact tinting of the walls of the model and of the opposing building, Mr. Waldram pointed out that exact correspondence could scarcely be obtained in inclement weather, and he claimed that the small differences shown in Fig. 9, which showed the last series of tests made, were only what might be expected when one observer was at work with a delicate instrument in a warm room and the other was taking simultaneous readings on a frozen flat in a cold wind, and that had the results corresponded exactly under such circumstances they would have been open to question. He mentioned that some years ago he had in summer weather obtained identical results in a larger model in the summer papered with the same paper

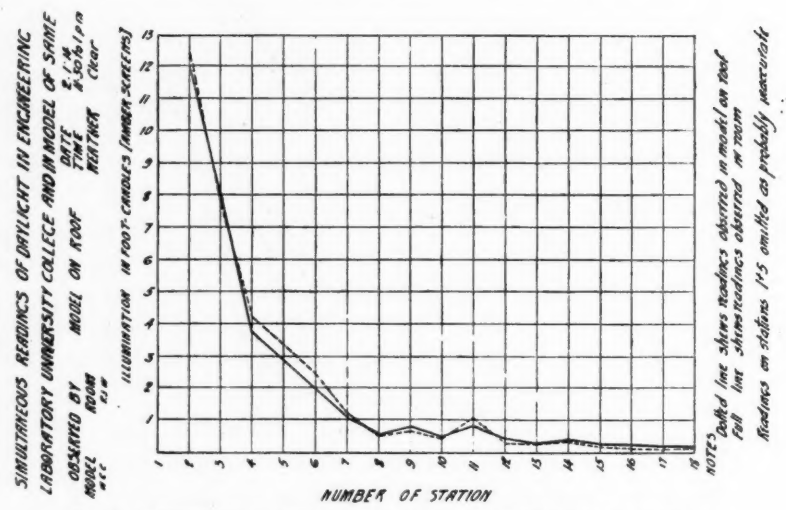


FIG. 9.—Comparison of actual readings of daylight illumination in a room and results obtained from small model.

as the room, a somewhat important detail.

He suggested it was scarcely possible to exaggerate the importance of severe actual tests of the accuracy of observations in models as opposed to mere opinion.

MR. A. P. TROTTER asked what was the relative scale of the model.

MR. WALDRAM said it was a scale of a quarter-inch to one foot, which was, however, decidedly too small, and it would have been better had the model been double that size. The room was 36 ft. by 50 ft.

MR. TROTTER, continuing, said that the paper practically dealt with three subjects: (1) the general question of daylight and its measurement; (2) the rather special one of ancient lights; (3) school lighting. On the last occasion he was very pleased to hear school medical officers and others talking glibly of foot-candles, for it showed that the Society was really making some progress in its educational work. With regard to the first question sent out by the Society, namely, "What is the minimum natural illumination at which artificial light became preferable?" it had never occurred to him to inquire into this until he had read Mr. Waldram's paper. During the last weeks he had made many measurements of the daylight illumination received on his office table. On that day, at about 3 o'clock in the afternoon, although he did not think it worth while turning on the artificial light, he found it was only 0·3 foot-candle. Even then he had been able to continue working until 4 o'clock without turning up the light. On occasions he had found himself able to continue working until the natural light fell to as low as 0·2 foot-candle, and he attributed this to the fact that one hardly noticed the gradual fading away of daylight until it reached a point somewhere near this. These figures, of course, were very much less than had been suggested by some of the Society's foreign members, and he rather doubted whether they had actually made measurements before giving their figures. The second question sent out by the Society was, "What are the conditions of minimum sky brightness under which such minimum inside illumination ought to be obtained?" This was rather difficult to understand, but the second part of the question was easier, namely, "What is the minimum ratio which the inside light should reasonably be expected to bear to the outside?"

A large amount of data had been collected on this subject, chiefly by Mr. Waldram himself, and it would seem that it could be regarded as good lighting if one got five-thousandths of the outside lighting inside the room. Probably at about three-thousandths the lighting would begin to get rather poor. With regard to the other questions sent out, he had not sufficient knowledge to offer practical replies. Theorising or guessing about such matters was useless. Turning to another part of the paper, he regarded the new unit of the "square degree" as a very practical one. He had not the least idea, until he measured it, how many square degrees of sky light got into his room, which was lighted in two ways. On one side it was lighted from Whitehall, and faced a dingy classical building, and the light received was about 15 per cent. of the whole, whilst the rest of the lighting came from a skylight overhead. By the aid of a 4-inch focus ordinary reading glass he focused the skylight on to a piece of blotting paper, made a sketch of the panes, reduced it to a rectangle, and got the square degrees from that, and arrived at a figure of about 180 to 200 square degrees of light nearly overhead. He had been working with this for 13 or 14 years and had never found it uncomfortable. Some school authorities had distinctly condemned overhead lighting; this was perhaps due to the fear of rain coming in.

He had devised the zenith method of measuring daylight in 1895, and he understood that Mr. Waldram had thought of it independently at a later date. It consisted in comparing the outdoor with the indoor illumination. Any illumination photometer could be used with the test screen covered with a tube or chimney having a side tube like the spout of a coffee pot. On the top of the chimney a diaphragm is placed reducing the source of light to a small fraction, say 1/1,000th of the hemisphere of the sky. The test screen is observed through the side tube and a measurement is taken out of doors, or at a window. The instrument is then brought indoors and the tube removed and another measurement is made in the usual way. The ratio of these give a *relative* measurement of the degree of illumination in the room which is independent not only of the time of day, time of year, or weather, but of the standardising of the photometer, for the foot-candle readings cancel out. The measurement is a purely arbitrary one, but it gives consistent and definite results by which the degree of daylight illumination of one building or room can be compared with another.

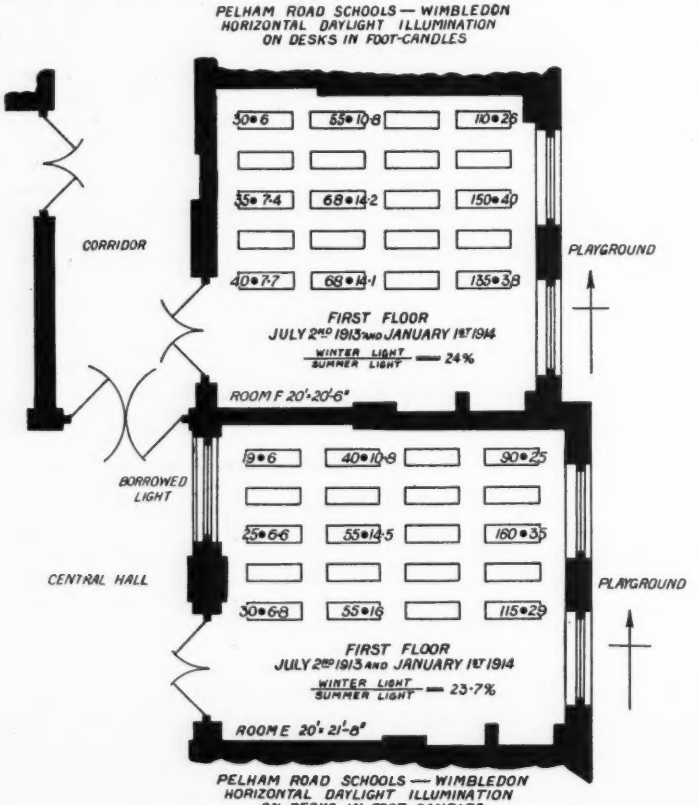
Another way of comparing sky light, which had been suggested by some Continental authorities, was to use a little mirror, reflect the sky, and compare the brightness of that with the brightness of the paper on a desk. It was a very similar method to his own, but we had so many grey days in this country that it was probably better to reduce the daylight to a definite measurement. By using this suggested Continental method there would be difficulties in getting really comparative measurements of schools, say, in a country like Italy and in England.

Dr. Bishop Harman had suggested 9 foot-candles as the minimum daylight illumination; he would like to know whether this was a "shot" or whether it was the result of a measurement. He personally could do with one-twentieth of that. The calculation of the value of reflected light upon walls and ceilings was a very complicated matter when dealing with a room, and probably it could be done better on a large model than in any other way. One of the Continental authorities had suggested that ceilings should not be whitewashed, but should be a pale yellow. He was of the opinion that the ceilings in this country should be as white as possible. In schoolrooms from one-fifth to a quarter of the walls might be whitewashed. The advantageous effect of this upon general illumination was very appreciable.

Mr. Waldram had suggested another method of comparing the outside illumination with the inside by utilising the sunset, but he would like to see more figures to be convinced that that would be a good criterion. It might be more liable to the effects of weather than the measurement of the zenith sky on a grey day. There was another method which would probably appeal to some people, perhaps, more than the use of a photometer, namely, the darkening of a photographic paper in a suitable screen.

All sorts of screens were now commonly used by photographers, and there should be no difficulty in getting a screen with a suitable paper to darken proportionally to the general visual effect upon the eye. Years ago he used ordinary slow bromide paper for street lighting work, which he carried up and down a street. Then he exposed some paper to various degrees of foot-candle illumination, developed the two in the same dish, and found some sort of agreement with the mean of a number of street measurements by a photometer. This might appeal to some people, as it was a fairly simple way of carrying out the measurement.

It had occurred to him long ago that in public buildings, such as libraries, large rooms in clubs, &c., it would be perfectly possible to have a small photometer fixed in the room in an inconspicuous position, such as one of Mr. Harrison's new lightometers—a little box containing a small lamp, with a Bunsen screen—and to instruct the man in charge of the lights to switch on when he could see the spot began to disappear or to become bright. The club waiter, for instance, would be told to switch on the lamps when he saw the light coming through the spot, and to switch on enough to darken it. It would relieve him of the responsibility of judging when to turn on the lamps. It might be remembered that fully twenty years ago Mr. Shelford Bidwell exhibited at the Physical Society a little selenium cell relay and a lamp, and this cell, as the daylight faded, acted as a relay and turned on the lamp automatically. A good deal had been done in recent years with selenium, and different materials sensitive to light, and something of that sort might be done. If the day gradually became dark in the middle of the day, and the daylight illumination went down to, say, three-quarters of a foot-candle, this lamp would be automatically lighted,



but if the daylight went up to 5 or 6 foot-candles some means would have to be provided for turning down the artificial light. With regard to the eye rejecting more than 1 foot-candle, as had been suggested by Mr. Waldram, he thought this required a little modification or explanation, and a physiologist would have to be turned on to the problem before they got to the bottom of it. This was a subjective matter.

Prof. W. C. CLINTON remarked that the curves shown by Mr. Waldram, having reference to the illumination in a room and its model, were in very fair agreement at those stations near the windows, where most of the light came direct from the sky. Further back in the room, where this direct light was lost, and the illumination was due to reflection from the building opposite, there were rather large percentage differences, undoubtedly due to the difference in colour of the model of the building and the building itself.

Returning to the immediate subject of Mr. Waldram's paper, he thought that an account of some tests carried out by a Sub-Committee of this Society on the Day Lighting of Schoolrooms might be of interest.

Through the courtesy of Dr. Nash, classrooms in the Pelham Road School, Wimbledon, were placed at the disposal of the Sub-Committee, and photometric measurements were made at corresponding points on the desks of two neighbouring rooms on each of the three floors of the building, in July and January. Readings of the zenith brightness of the illumination on the window sill outside the room were taken at the same time, the lumeters used having been tested against one another and found in agreement.

The ceilings of the rooms were white, and the upper part of the walls were cream colour, estimated to have a reflecting value of about 70 per cent. of that of the lumeter test card. A set of measurements taken for the first floor rooms is shown.

The lower values in the back desks in Room E, as compared with Room F, are probably due rather to their greater distance from the window than to the reduction of reflecting wall surface by the presence of the borrowed light. The vertical angle subtended by the window head from the far end of the back desks in Room E was 27½°, the height of the desks being 2 ft. 6 in.

The July measurements of zenith brightness were quite unreliable, as the day was sunny, with detached masses of quickly-moving white cloud passing over the sky. The sill readings taken on window sills facing west, between 12 noon and 1 p.m., were found much more constant, and these were used. It is recognised, however, that reliable zenith readings would in general be the better to refer to.

The table below shows the values of the sill ratios obtained:—

RATIO BETWEEN ILLUMINATION ON WINDOW SILL AND ILLUMINATION ON WORST LIGHTED DESK, PELHAM ROAD SCHOOLS, WIMBLEDON.

		Illumination on back desks using yellow screen (ft.-candles).		Illumination on window sill using yellow screen (ft.-candles).		Ratio.	
		Summer.	Winter.	Summer.	Winter.	Summer.	Winter.
Ground Floor:							
Room E	x	4·5	2·6	500	300	1 : 110	1 : 115
	y	6·0	3·3	500	300	1 : 86	1 : 90
Room F	x	—	3·0	—	300	—	1 : 100
	y	—	—	—	300	—	——
First Floor:							
Room E	x	8·5	2·0	800	300	1 : 95	1 : 150
	y	10·5	2·6	600	300	1 : 57	1 : 115
Room F	x	—	2·2	—	300	—	1 : 135
	y	—	2·6	—	300	—	1 : 115
Second Floor:							
Room E	x	9·0	2·9	1000	350	1 : 110	1 : 120
	y	11·0	—	1000	350	1 : 90	—
Room F	x	7·5	2·6	600	300	1 : 80	1 : 115
	y	10·5	—	600	300	1 : 57	—

(x) indicates illumination on back desk in row most remote from window.
(y) indicates illumination on front desk in row most remote from window.

Some schoolrooms in Derbyshire which the Sub-Committee, through the kindness of Mr. Widdows, were enabled to examine, gave sill ratios very similar to the above.

It would appear that a minimum value of either the sill ratios or the zenith ratio could be fixed as a basis upon which to devise building rates. If sill ratios are taken, it would be somewhere in the neighbourhood of 1 : 100, but a very much larger and more systematic inquiry is needed before any authoritative statement could be made.

H. L. DUNSTALL, A.R.I.B.A., said it was with diffidence that he ventured to express any opinions on the subject of lighting before a Society engaged in the scientific investigation of illumination. But as an architect engaged in the designing of school buildings, a few observations might not be out of the way.

Dr. Nash at the last meeting made the remark that architects design schools and leave them to others to administer. Perhaps this is so, but the school architect has by no means a free hand, he is to a very great extent tied down by the demands of the educationists and his buildings have to be designed so that some particular system of teaching may be carried out. Most of the old schools owe their form and arrangement to the system of teaching which happened to be in vogue at the time of their erection, and from the plan of a school it is possible to tell the approximate date of its erection.

Late in the XVIIIth century a school consisted of a large oblong room with desks grouped in the centre with windows on both sides. About 1825 the room became longer in proportion to the width, at one end of which was a gallery and along each side of the room were groups of desks, facing each other and forming what is called the double bank type of school. Still later, say from 1860 onward, the development of the pupil teacher system led to the adoption of a long narrow schoolroom, lighted from one side as a rule and with a large gallery at one end. The groups of desks were placed back to the light and often divided by curtains. This type of school was the fashion until about 1880.

The Ben Jonson school, built 1872, was a great innovation at the time and the result of a competition. It is interesting, as being the prototype of the modern elementary school, and nearly all the rooms were lit from the left-hand side. It is curious to note, however, that this found very little favour with educationists at the time, and for another ten years the long, narrow schoolroom was adhered to.

From this plan the corridor type of school, consisting of a long corridor with rooms opening out on both sides, was evolved. As time went on, the width of the corridor was gradually increased and the classes were divided by walls or partitions, until at the last the plan reverted to the Ben Jonson type. This has continued with minor alterations and improvements in lighting until within very recent years. At the present time there is a most extraordinary diversity in school planning chiefly due to questions concerning ventilation; the lighting of the classroom still remains unilateral for the most part, except in some instances where the tendency has been to adopt bilateral lighting.

The decrease in the size of the classroom during the period just reviewed is remarkable. In the early days one master with the help of monitors managed several hundred children. With the pupil teacher system it was not unusual to have classes of 70 and 80. Later 60 was looked upon as the maximum, and now in the London area all classes in the Infants Department are to be reduced to 48, and in the Senior Department to 40.

As was to be expected, improvement in the lighting of the schools followed the reduction in the size of the classes. In old schools some desks were frequently 30 ft. from the window wall. The 1907 Building Regulations of the Board of Education limit the width of a room in the absence of supplementary light to 24 ft. 8 in. He quite agreed with Dr. Nash that a room of this depth is often not properly illuminated, particularly when a school is surrounded by high buildings and all low-angle light is cut off. The architect is not to blame for this, so long as education authorities insist upon rooms of 50 and 60 this difficulty will occur. Rooms of 50 places are

specially badly proportioned, the width from the window being greater than the length. A room of 48 places has much better proportions, the width in this case being 20 ft., and the length 24 ft. A room of 40 is practically 20 ft. square.

Mr. Dunstall added that he could not agree with Dr. Nash that a room approximating to a square is unsatisfactory, except as regards rooms of 50 and 60 places. In his opinion a room of 40 places in which there are five rows of dual desks, approached the ideal classroom.

On the contrary, he considered that in the German classroom referred to by Dr. Nash the length is very excessive as compared with the width. In one view, he counted no less than nine rows of desks, far too great a number for the effective supervision of the class by the teacher.

As regards bilateral light he was fully convinced that it is a mistake; it seems to give rise to conflicting shadows which are undoubtedly very trying to the eyes. Mr. Widdows, in his endeavour to avoid the Charybdis of poor illumination, fell foul of the Scylla of bilateral lighting. Supplementary windows high up do not appear to have any undesirable effect and they do not add materially to the amount of reflected and diffused light in a room.

He could not endorse Mr. Waldram's suggestion that front light is good. In a classroom it would have the effect of throwing the blackboard or diagrams in shadow.

Although skylights are tabooed in the 1907 regulations, the Board of Education permit their use for the purpose of improving the lighting of old buildings. He agreed with Mr. Waldram that top light had an enormous lighting value and greater use might be made of them provided it was in combination with lateral lighting.

This stipulation is necessary because top or high-angle light alone gives a very dreary and depressing effect to a room; on the contrary low-angle light has a cheerful effect, and therefore a beneficial influence upon the human mind. It was an open question whether Mr. Widdows was not making a mistake in relying practically altogether on high-angle light in the new North Wingfield school illustrated by Dr. Nash at the last meeting.

Mr. Dunstall remarked that it had come within his province to remodel several old National Schools. Unfortunately most of the early schools were designed by Church architects with a strong leaning towards the Gothic style and their ideas of school lighting were most extraordinary. The windows were seldom less than 6 ft. from the floor, and those in the gables were much higher. The roofs were invariably open to the apex, and, though in many cases of good design, the darkly stained timbers were wholly unsuitable for a school or any building where a maximum amount of light is required.

The improvement obtained by painting these roofs in a light colour and distempering the walls white to a picture rail well below the plate level, is most surprising. This treatment, together with alterations to the windows, has been the salvation of many old schools. In several cases, he had suggested ceiling the roof at the plate or collar level, which had the effect of adding very considerably to the value of the reflected light.

Dr. Nash's remarks as to the colour of walls he could fully endorse, and although in all cases it was not convenient to observe exactly the proportion of white or green suggested by him, he had for some years past followed the principle of making a deep white frieze.

Mr. Dunstall also showed several lantern slides illustrating a few points touched upon. Of special interest was a ground plan of a scheme for rebuilding a church school at Newington Butts. The site is a somewhat congested one, and surrounded with high buildings, and to obtain adequate light practically the whole of the window side of the room is glass. The glass area is nearly one-third of the floor area. In the classrooms a line drawn from the far desk to the top of the window makes an angle of 31 degrees. This will be a three-storey building with a roof playground.

In conclusion Mr. Dunstall said he would like to express his appreciation of Mr. Waldram's most interesting and useful paper and his thanks to the Society for its kind invitation to be present.

Mr. C. C. PATERSON said it was a general impression that more illumination was needed by daylight than by artificial light, and if this were so, separate scales would have to be allowed for artificial and for daylight in any rules prescribing what is adequate. As far as he had been able to judge, however, this was not so, for taking the case of a number of corridors, he had found the illumination by daylight very low, and yet it seemed sufficient, that is to say, one could not say that the corridor was really badly lighted, and yet the same amount of artificial illumination would probably be deemed insufficient. He agreed, however, that there were probably exceptions to this.

The daylight ratio of inside to outside illumination which Mr. Waldram had spoken of was a very useful one indeed, and would, he believed, become standard. What had surprised him very much was the small values which this ratio had, even in buildings composed almost entirely of glass, but probably the dirtiness of the glass accounted for this. He thought that one of the reasons why top lights had not been encouraged in schools was that in the event of snow falling on them it would very much diminish the interior lighting, and he understood that this was one of the chief objections to depending for illumination on top lights.

Mr. Trotter had mentioned the difficulty of comparing schools in Italy with schools in this country, and suggested that some different standard would be required for both cases. The speaker was not quite in agreement with this suggestion. We really required to judge of the relative adequacy of illumination in Italy and England only when the illumination had a relatively low value, such as towards the end of the day in winter. He agreed that if the entrance of sunlight into a room had to be considered the matter would be a complicated one, but these were not the conditions under which one really wished to judge of the adequacy of lighting in any two countries.

The main thing that he wished to call attention to in regard to the paper was the "minimum allowable ratio of inside to outside illumination," and one of Mr. Waldram's methods of recording daylight measurements. He wished to protest against the system of giving daylight illuminations in terms of zenith readings taken with the daylight attachments which are fitted by makers to some photometers at the present time. He had no serious objection to zenith readings *per se*, provided it was understood that such readings were only made because no other method could be used in the position in which the measurement was desired. If one had a place surrounded by buildings and could not get on the roof to take an open illumination reading, it was impossible to get a proper daylight observation, and one must then take a zenith reading and assume that the whole hemisphere of the sky is of the same brilliancy as the zenith, and deduce the resulting illumination. But, unfortunately, as had been implied in the paper, present daylight photometers do not take account of the fact that the cosine law comes in, and that the resulting reading of illumination obtained gives a value which is really twice as high as it ought to be. The case, indeed, is worse than this, because the sky is never evenly illuminated all over; towards the horizon there is nearly always more absorption of light, so that the values obtained are liable to be more than twice the correct figure, and seriously misleading results follow as a consequence. To obtain an idea of the meaning of readings taken with the zenith attachment, it is first necessary to imagine that the sky is equally illuminated all over. One has then to suppose that all buildings have been removed and also that there is no such thing as a cosine law. The result of this mental effort is the conception of an entirely imaginary unit which has no direct relation with foot-candles, and he did not think that such a conception ought to be introduced into our nomenclature of daylight illumination. Surely it was quite easy to reduce all figures, zenith figures or not, to what the illumination actually is under the clear hemisphere, and the daylight factor which we ought to take for buildings is the simple one of ratio of illumination on the roof to that of the illumination at a given point inside the building. It would be perfectly easy to use zenith readings if makers would only make the holes in the daylight adaptors half the area adopted at present, in which case the zenith readings would give a reasonable

approximation to the true illumination on the roof. Therefore, he sincerely hoped that this suggestion, if it appealed to the Society, would be supported by some of those present who were pioneers in daylight work, so that others interested could understand the science. At present he was sure that even technical people would never grasp what was meant. The man in the street was now beginning to understand foot-candles, and therefore we should try to keep things as simple as possible and avoid unnecessary errors. He concluded by congratulating Mr. Waldram upon his very excellent paper.

MR. PERCY L. MARKS expressed his interest in Mr. Waldram's statement as to the uncertainty of the human eye, than which, he agreed, there was nothing more uncertain. Architects knew a great deal about this, because they had, from the very earliest period (or, at any rate, from the palmy days of Athens), introduced optical refinements in order to correct optical delusions. One thing to be borne in mind in regard to daylight illumination or illumination of any kind, in regard to photometry, was the large number of factors which affect the apparent amount of light in any room. There was a great deal to be considered from the point of view of individual capacity for seeing light, there was a great deal as regards the decoration of the room, and there was a great deal as regards the artificial furnishing of a room. A simple instance was the effect of light upon a white table cloth compared with a coloured cloth, and how any scientist could be expected to give a photometrically correct amount of light seemed to him to be an impossibility.

There were two extremes with which the architect was confronted from the very beginning in regard to any building. If he could not get the correct amount of light, should he have too much or too little? Both extremes were bad, but most architects were agreed that it was best to have a little too much than a little too little. But how were they to get it? It was generally accepted as a matter of experiment. The late Joseph Gwilt formulated a proportion which had been more or less accepted, namely, 1 ft. of glass area for every 70 cubic ft. capacity of the room. Thus in a room 12 ft. by 14 ft. by 10 ft. there should be a window 6 ft. by 4 ft. In many cases that would be adequate, but when one remembered all the variable factors, even that could not be considered entirely satisfactory.

He was very pleased to see that Mr. Waldram had stated that we must beware of pursuing ideals too far; it was certainly necessary to use caution in applying them to daylight illumination, and in this case the method must be empirical after all, and (as he thought) measurements were of doubtful utility to architects.

Mr. Trotter had referred to some people's objection to whitewashing ceilings. Personally he thought that the objection was deplorable, because in the average room there was a lot of light reflected down, the value of which could not be magnified.

Mr. W. H. WEBB was called upon to speak, but said that he would prefer to send in a contribution to the Journal.

Mr. J. S. DOW (Asst. Hon. Secretary) read out communications received from Mr. T. E. Ritchie and Mr. Edward Warren and also replies from Prof. F. K. Richtmyer and Prof. Max Gruber to the list of queries on daylight illumination. (See pp. 89, 97.)

DR. F. GANS expressed the opinion that although there had been much discussion we did not seem to have made very much progress. An important question was the minimum daylight necessary at the worst-lighted desk, and views upon this question seemed to be very divergent. It would be necessary to come to some agreement on this. The test might be the capability of reading diamond type at a distance of about 12 inches from the eye. After all, human beings were not scientific automata, and the eye is not a scientific instrument. Therefore the test ought to be a practical one, and if such a test as that prescribed (see Hermann Cohn, 1867) could be complied with then it might be said that the light was sufficient.

In Germany myopia is more common than in this country, and the Germans are

called a shortsighted (myopic) nation. Here is not the place to investigate the causes of myopia, but certainly one of the commonest is eyestrain due to insufficient light. Perhaps this was brought about in the case of children by excessive homework, which was carried out under conditions of poor illumination in the homes.

Personally he thought there could not be too much light in the school, provided glare and other obnoxious conditions, such as irritating reflexes, direct sunlight, &c., were avoided. On this basis there was no question that the more light the better.

With regard to Mr. Marks's comment, he thought it was not just to belittle the efforts of the scientist, from whom, after all, the architect could learn a good deal.

Last year he had attended the medical congress in the Albert Hall, and was astonished at the amount of light there. Would it be possible to design schools something after the manner of the Albert Hall, with a circular bay and top light ?

Mr. V. H. MACKINNEY said that much of the original data which had been forthcoming in Mr. Waldram's paper would be of the greatest possible value, even to the lighting engineer whose work was connected mainly with artificial lighting. The variation in daylight from the window towards the back of the room was often very considerable—far in excess of what would occur with artificial light. This was a point which should be borne in mind by those who claimed for any system of lighting that it resembled daylight exactly.

He agreed that a mixture of daylight and artificial light was decidedly inconvenient, and thought it might even be desirable to shut out the daylight completely, in basements where artificial light was necessary all day.

Not only had the members to thank Mr. Waldram for the data in his paper, but they had to thank him also for the fact that his paper had brought from Mr. Trotter the suggestion with regard to an "indicator-photometer" which, placed in a corner of the room, would signal when the time to turn on the artificial light had arrived. This would be of great practical value in schools and large buildings, and might prove a practical and probably inexpensive proposition.

Mr. Paterson had advocated a modification of the "daylight attachment" used with several modern photometers. The suggestion that the area of the aperture of the tube should be diminished by half would be easily carried out. In designing the attachment to the Holophane Lumeter they had followed previous usage, as it seemed best that all instruments using this device should be consistent one with another. But if it was generally agreed to make the change Mr. Paterson advocated, this could be easily done.

Another point that had still to be decided was whether acuteness of vision with a daylight illumination of one-foot-candle was distinctly different from that existing with the same illumination by artificial light. Some valuable data might be obtained by careful measurements of the aperture of the pupil of the eye under both conditions. Could we record with some degree of accuracy the average pupil diameter for daylight and for artificial light with definite values of illumination, diffused or otherwise, this might be some guide as to how far the same standards of illumination would apply in the two cases. It might be found that a different value of illumination would be needed to give the same pupil aperture and the same visual acuity respectively by natural and artificial light. Claims had sometimes been made that with certain systems of lighting a smaller illumination in foot-candles was necessary to produce a certain visual effect, but he did not believe these claims could be substantiated on present data and without further research. Moreover, it seemed probable that conditions resembling daylight (*e.g.*, very large illuminated areas overhead, &c.) might cause a contraction of the pupil aperture, and would therefore lead to a higher illumination being required on the working plane in order to produce a given effect on the eye.

With regard to the use of top lights and north skylights, these gave shadows but with very smooth edges. Far from not admitting enough light, they frequently admitted too much, unless

provision was made for shading. In this connection he referred to a factory in which he had worked, and which was lighted in this manner, where the top light was whitewashed over in the summer.

He was much interested in the tests described by Prof. Clinton, but was rather surprised that the values of the "sill-ratio" differed so greatly in summer and winter. Presumably this ratio should be the same whatever the sky-brightness.

Mr. LEON GASTER expressed his appreciation of the paper and the many interesting debatable points to which it had given rise. He thought that a special word of thanks was also due to the foreign authorities who had come forward and given their experiences on the matter, thus enabling the Society to send a collection of opinions from various quarters such as he thought had not been provided before.

He believed that there were a few members who were inclined to think that daylight illumination was somewhat outside the scope of the Society. This was a very short-sighted view. In order to understand in what good artificial lighting consists, one must study daylight. In whatever direction one looked one found cases in which daylight and artificial light problems overlapped, and in particular they provided common ground for the architect and the lighting engineer. He felt sure that in time to come these researches on daylight illumination would be regarded as among the most important pieces of work carried out by the Society.

THE CHAIRMAN said everyone must agree that this was one of the most valuable of papers and that the discussion had fully emphasised its importance. Although as had been suggested there had been no startling advance, we had at any rate levelled up our knowledge, and integrated all the small advances in various quarters into a solid front, which would lead to still further progress in a short time.

Minimum illumination was not a question of how much daylight persisted till it was time to turn on the lamps. Various people could work with small quantities of illumination, and in this respect practical experience would have to be relied on. In schoolrooms the great factor was the brightness of the window area. The eye might become twenty times as sensitive if the window brightness was slowly and sufficiently reduced, so that whilst at 4 o'clock one might see with a third or a fifth of a foot-candle. at noon one might not do with less than say five foot-candles. He had been sometimes surprised at the comparative darkness of corners of rooms as judged by the eye, perhaps a half-foot-candle being estimated where the photometer gave eight or ten. The light adaptation of the eye had nothing to do with the size of the pupil, but was a condition of the retina largely controlled by the brightness of the window. Among the communications received from the Continent an estimate of about 10 M.K. (red light) was general. This corresponds to 25 or 30 metre-candles with white light, which is approximately our recommended minimum for artificial illumination.

The zenith brightness as a reference standard had been criticised, but it gave a valuable relation so that some such method as recommended by Mr. Waldram or that used by Weber and Cohn would likely be adopted. Some standard in relation to sky area reduced to square zenith degrees, if one could use such a term, would be of great service. Roof lights had been objected to partly on account of snow, but in England that at least might be left out of account. Positions of windows, other than for left lighting, were useful in natural ventilation, but if used it should be with reflectors, so that the light was wholly reflected from the ceiling, thus avoiding interfering shadows.

These considerations of various difficulties show that the Sub-Committee on School Lighting will not find it easy to make a scientific statement as to daylight, and he hoped that when presented their report would on this account receive very sympathetic consideration.

Mr. THOMAS E. RITCHIE (*communicated*) :—

I regret very much that a previous appointment prevents my attendance at the reading of Mr. Waldram's paper, as I consider it quite one of the most

important presented to the Members of this Society.

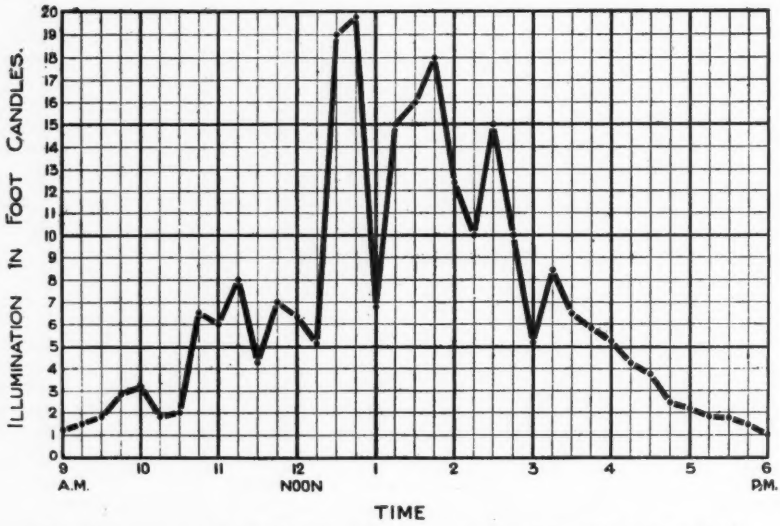
The question of the provision not only in the School, but also in the home, the office, the factory and the workshop of a satisfactory daylight illumination is of paramount importance; whilst the high esteem in which Mr. Waldram is held by those acquainted with the extensive and painstaking character of his work in this connection renders him perhaps more qualified than any other Member of the Society to give to the study of this subject the emphasis which it undoubtedly merits.

The nature and extent to which the daylight illumination of a given room normally varies not only from day to day and hour to hour, but, under certain circumstances, almost from minute to minute, is a matter of surprise to all those first confronted with the results of actual measurements systematically carried out.

I have for some time past made careful measurements in a number of offices and factories. The results obtained, some of which have been plotted in the form of curves, quite bear out Mr. Waldram's figures as to the variations commonly met with and his statements as to the time and trouble involved and the great expense incurred in the carrying out of such work.

The curve reproduced (see figure) may be taken as typical and is interesting as corroborative evidence of the accuracy of the data furnished by the author's Figs. 3, 4 and 5.

In the case in point, which represents the variation in the daylight illumination of a well-lighted London Office, readings were taken by two observers every fifteen minutes from 9 a.m. to 6 p.m. The variation shown is roughly between 90 and 95 per cent., but it will be noticed that many very large variations occurred within comparatively small spaces of time.



Typical Fluctuations in Daylight Illumination in a London Office (Mr. T. E. Ritchie).

It should also be noted that the lighting of the office in question was such that no direct sunshine could fall upon the desk upon which the measurements were made, had it been otherwise the variations must have been very considerably greater. As it is the fact that such may, and commonly do, occur, serves to indicate the immense amount of labour incidental to the securing of the very large number of readings necessary if their adverse effect is to be eliminated and anything in the nature of a true average secured.

It may also be of interest to those of a more utilitarian frame of mind to learn that the question is not only of academic interest, as is often supposed, but has in certain cases a direct and immediate bearing upon not a few important industries.

In quite a number of cases the variations inseparable from daylight illumination have proved so serious a drawback to efficient working that now that artificial daylight is so readily available many firms have discarded daylight altogether for certain processes and are, for instance, carrying out the whole of their matching and inspecting entirely by the aid of a colour-true artificial light, the average intensity of which can be maintained within comparatively small limits and the use of which has resulted in greater ease and certainty in working, in an indefinite extension of the hours in which the work can be carried out and in the securing of an output of a considerably more uniform character than was previously obtainable.

Finally as touching upon the work of the Committee of this Society now investigating the question of the daylight illumination of schools and which is, in this connection, so indebted to the work of Mr. Waldram, it occurs to me, knowing as I do the difficulties of the work and appreciating as I do the very great value especially to the cause of education of the results of the Committee's labour, that some substantial grant should be made towards the expenses of this section of the Committee's work. Doubtless this would enable them to prosecute their researches further and obtain yet more valuable results.

Mr. EDWARD WARREN, F.R.I.B.A., F.S.A. (*communicated*) :—

Daylight illumination is one of the prime considerations to an architect in dealing with the buildings with the design of which he is entrusted, but the consideration of windows, their size, position and character, is not limited entirely to their efficiency for purposes of illumination. They have to be considered also, of course, for purposes of ventilation, and form extremely important architectural features, both externally and internally, of the design of any building.

The problem of daylight illumination differs greatly in buildings of different character. For instance the illumination of a hospital will naturally differ greatly from that of a domestic building, or a church, and the different departments of a hospital require very various treatment in respect of daylight illumination.

The wards must be well lit and ventilated but not overlit, and the windows must be so placed as to allow for the proper spacing of beds along the sides of the room and for providing effective illumination without a light distressing to the patients.

Operating theatres, post-mortem rooms, dissecting rooms and the like, require an extreme amount of daylight illumination, and in practice it is generally found necessary to give them overhead light by means of skylights placed at an angle of from 25 to 30 degrees, and of course to face them if possible to the north or north-east.

It is very desirable also to illuminate similarly laboratories such as clinical or bacteriological laboratories, where minute microscopic research is carried on.

As it is by no means possible always to obtain light through an external wall for all portions of a hospital or any other building, I have found that in practice an admirable means of vertical lighting for corridors, lobbies, &c., is by means of cast elliptical dome lights, which are remarkably successful, relatively inexpensive, and capable of being made absolutely watertight.

The daylight illumination of a church is a different problem altogether and requires great care and judgment in the disposition of the windows, as the illumination of the chancel should differ from that of the nave and aisles, and while it is desirable to provide adequate lighting it is always advisable to secure a quiet effect and the absence of glare. Where possible I think it is well to omit altogether the east window of the chancel, or at least to place it so high in the east wall that the congregation at early morning service should not have the low sun straight in their faces. West windows are well if kept small or placed very high

so that the relatively low and very strong sunshine of the summer should not fall uncomfortably upon the backs of the congregation.

In a church, however, the factor of stained glass greatly mitigates such considerations.

Some consideration of the character and qualities of the refracting properties of various types of glass may possibly form part of your discussion, and I think this extremely important, especially so in London, or large cities, where a great many portions of buildings have to be lit from wells, and where many windows get no direct sunshine whatsoever.

The use of reflectors is another important portion of this subject. In regard to schools, of which I have been responsible for the design of several, I think that the accepted rule of 4 ft. high from floor to window sill should be broken in the case of infant schoolrooms where 3 ft. or 3 ft. 6 in. might well be adequate. It is perfectly possible to overlight a classroom and to make the light distressing to the eyes of children when their gaze is concentrated upon white paper.

Mr. J. S. Dow (*communicated*) :—

The account of the tests on the small model undertaken by Mr. Waldram and Mr. Clinton was one of the most interesting things in this discussion.

When a large number of buildings of identical type have to be constructed and when daring expedients as regards window space are tried for the first time, the method should surely be worth considering. In one respect it is more easy to apply the method in the case of artificial light. The scale of the model would not have so much influence on the degree of reflection from walls and ceilings, because as the dimensions of the room increased, so, also, would the area of the windows. On the other hand, if one attempted to predetermine artificial illumination in this way one might not feel sure that the degree of reflection from walls and ceilings in the model was the same as would actually exist in practice.

The general opinion seems to be opposed to bilateral lighting for schools. The disadvantage of shadows owing to windows on the right is obvious. But in the case of the desks most remote from the window the fact that the light strikes the page at such an oblique angle is clearly a drawback to unilateral lighting. There seems little doubt that good overhead lighting is preferable when obtainable, and it may be asked whether, in the case of country schools, this method could not be more fully employed.

I have heard of some cases in which the habitual preference given to unilateral daylight illumination has led authorities also to place their artificial lights down the left side of the room. Surely this is a mistake. By scattering the artificial lighting units, and making judicious use of reflection from walls and ceilings we can get light striking the desks from many different directions which would seem to be better than light coming only from the left. This is interesting as an example of the misapplication of lessons learned from the study of daylight.

It is interesting to observe how closely Weber's proposed minimum value ($\frac{1}{2}$ per cent. of the outside illumination) agrees with some of Mr. Waldram's figures. In some cases there might be a little doubt as to where the inside illumination should be measured. In a schoolroom, clearly, it should be taken on the worst-lighted desk. But in a factory the right place is less certain and the position selected would often make all the difference to the daylight ratio.

I agree with Mr. Paterson as regards the desired correction in the daylight attachment. Mr. Mackinney has explained how this difficulty arose. But in any case this form of measurement is somewhat arbitrary owing to the variations in sky-brightness from zenith to horizon. There is little doubt that when it is possible to open a free horizon, or even illumination from an unobstructed quarter sphere, this is preferable to calculations based on measuring the brightness of a very small part of the sky. The "sill-ratio" method seems likely to give more consistent results for classrooms than measurements with the daylight attachment. It is interesting to observe that the figures for the sill-ratio given by Mr. Clinton are again in good agreement with the proposition of Prof. Weber.

There is one point brought out in Prof. Weber's contribution that should

interest Mr. Waldram. He points out that the illumination in foot-candles derived from an unobstructed sky of uniform brightness is equal to the surface-brightness of the sky in foot-candles. If, therefore, one could only make an instrument which could be pointed at the sky and would thus measure its surface-brightness direct, this would seemingly do away with the need for any daylight attachment, and would give a direct value for the unrestricted daylight illumination out of doors.

MR. P. J. WALDRAM, whose remarks at the meeting were curtailed owing to the lateness of the hour, referred first to Dr. Kerr's remarks at the previous meeting as to the need for some direct method of measurement—a point which had also been raised by other speakers. He expressed the opinion that what is needed is not so much accuracy as a common-sense appreciation of the real nature of the problems.

Mr. Farrow had stated that everybody was well acquainted with the fact that our eyes are bad instruments for the estimation of any degree of the value of light, but he personally could not help feeling that everybody was *not* acquainted with this; certainly Mr. Farrow's experience as an expert should lead him to agree that such general knowledge had not made itself evident in many ancient light cases, where the eye was implicitly trusted by different experts. Mr. Farrow, in commenting on the scheme of dividing up of the hemisphere of the sky in order to allocate its different values, suggested that it would probably be found the cosine law applied laterally as well as vertically. That was a very easy way of getting over the difficulty, but unfortunately it did not take account of the great difficulty with regard to the diffusion of light by the time it had entered a room. It would be necessary to allocate the different values of the hemisphere not only with regard to the effect they would have upon a piece of paper on the sill of the window, but it would also be necessary to allocate the different parts with regard to the effect on the average room, and that was not quite the same thing.

Dr. Nash had been very severe upon architects, and had said that the majority of architects designed their schools largely with regard to the architectural amenities of the district with the class-rooms as an afterthought. He did not consider that to be a fair view, and would point out that architects had a great many difficulties to put up with. They had an enormous number of problems to fit into each element of their design, like the different pieces of a jig-saw puzzle. Considering that not the least of these problems were the requirements of the Board of Education, and the personality of Committees, it was rather surprising that in this country with which least, there should be so little in the modern elementary school for the medical officer could find fault. The difficulties that an architect had to put up with were emphasised by Dr. Nash himself in his appendix to the discussion, where one authority suggested one kind of lighting with which his Government would have anything to do; and some medical authorities were in favour of lateral lighting with high back lighting, whereas others regarded high back lighting as extremely bad. What was the poor architect to do under these circumstances? Dr. Nash had also complained that the architect regarded the medical officer as a kind of weird person with no *locus standi*, but when the architect received such different advice from different medical officers he personally could not wonder at it.

With regard to bilateral lighting, there was one point not considered in its universal condemnation, namely, that in a room lighted from two sides purely bilateral lighting was only obtained in the middle of the room. Towards the ends of the room the nearer window was very much stronger than the other. In the schools which they had seen in Derbyshire, where Mr. Widdows had lighting on two sides, the greatest difficulty was found in the centre of the room, and very little difficulty was found under each particular window. In cases where bilateral lighting was unavoidable, he suggested a low glazed screen to shade the central desks as likely to overcome most of the difficulty.

He welcomed the independent corroboration of Mr. Trotter and Mr. Patterson

of the figures given in the paper as to the amount of light required by the eye in twilight. This was a very important point, because good or bad daylight illumination was not merely a question of amount; yet in so far as the amount of light available governed any problem it was merely a question of how long was the period between sunrise and sunset when the light fell to below the requisite level.

He would scarcely regard a ratio of three thousandths (of the unrestricted outside illumination) as in any way poor lighting, and thought that for ordinary purposes a ratio of one to two thousandths would generally be regarded as quite adequate.

He regarded Mr. Trotter's suggestion with regard to a by-pass to enable the teacher to light up at the proper time as being one of great value, and he would certainly do everything he possibly could to get it into practical use at the earliest possible moment. Mr. Trotter had also mentioned Thorner's method of relative photometry. This instrument depended absolutely upon seeing the sky from some part of the room, but anybody who had studied the subject would know that it was possible to get a reasonably well lighted place in a room where no sky could be seen.

Mr. Trotter had suggested that wall surfaces should not be white. Practical architects knew that white should never be used as a wall surface because it would look blue. It must be "broken," and generally it was mixed with a little burnt umber, or more preferably green. Personally he preferred white broken with green for the upper parts of the walls and a little extra touch for the ceiling of a schoolroom and a general shade of green for the walls below. The photographic paper method of measuring daylight was open to the objection that such methods take some time, and daylight could vary very considerably over quite a small period of time, and unless it was used with a knowledge of that fact, the results were apt to be misleading.

The suggestion of observing the illumination in a room at sunset on a clear winter's day, or at other times when the sky had an apparent brightness of 100 foot-candles, was intended merely as a simple criterion which anyone could understand, and in order to avoid the difficulties of explaining a ratio.

In suggesting that the eye probably refused more than one foot-candle, he had carefully confined himself to diffused daylight. He did not suppose for one moment that the eye did this in sunlight or even under direct light from the sky.

Professor Clinton had mentioned the large difference in the University College models due to light reflected from the walls. These walls were very carefully coloured, but not quite carefully enough, and it served to show how delicately a model reproduced the effect in a room. If the model were made even slightly incorrect the error was at once apparent in the results.

Professor Clinton also advocated sill readings for ratios, but he thought these were open to one grave objection. They were quite satisfactory if there was no horizontal obstruction, but whenever there was horizontal obstruction a palpable error was introduced. The only reason for the zenith being chosen as a criterion for ratio, was because it was free from obstruction, and free from sunlight, which was a very important matter. Mr. Patterson had also mentioned this point, and he agreed that it was not ideal, but it was applicable to all cases. It would obviously be preferable to use unrestricted roof light in a grey sky, but one had first to catch the grey sky, which was not easy, and then go on the roof to get it, which was often impossible, and the zenith light was frequently the only available method. With regard to another point raised by Mr. Patterson, it was well known that readings given in the ordinary daylight attachment to a photometer were double what they ought to be. This was generally recognised, and it was also recognised in the paper.

He had been frequently tempted to suggest that the apertures should be changed for the sake of uniformity, although it did not make the slightest difference as the ratio was only a convenient method of expressing a comparison. He had refrained, however, from doing so, because he found that the values given by the apertures as usually

constructed were also identical with the apparent brightness of the sky viewed direct: in fact, he had for some time generally used the screens and lumeter to check the aperture readings.

In connection with Mr. Dow's communication on this point, it would be interesting to know whether Professor Weber neglected the cosine law in calculating the total illumination from a hemisphere of uniform sky. If not, there was an apparent discrepancy when one found that the sky surface-brightness viewed direct was identical with an aperture reading which ignored the cosine law.

He welcomed Mr. Patterson's criticism which was very valuable, but suggested that perhaps the apparent difficulties would disappear if we could state the ratio as being between the apparent brightness of a white card in a room, and that of the zenith sky.

Mr. Dunstall suggested that in the South Wingfield School Mr. Widdows relied practically altogether on high angle light. It should, however, be noted that when low windows were provided, in order to mitigate the cheerless effect of high angle light alone, such low windows need not have any material illuminating value. This function was to provide aspect and ventilation, and this they did quite efficently in Mr. Widdows' schools from under a verandah roof.

Mr. Warren suggested the elimination of the east window in churches in order that it should not shine directly into the eyes of the congregation at early morning services. He scarcely thought that the suggested nuisance could be one which was generally serious. The sun was only due east at 6 a.m. all the year round, and was below the horizon at that hour from September to March, whilst its greatest elevation due east was only about 30° at Midsummer Day.

It would be quite possible to ascertain exactly where the sun's rays would fall anywhere inside a church at any hour.

Mr. Percy Marks apparently desired to adhere to the pseudo-science of a century ago as stated in Gwilt. We often came back to old rules after a long course of intricate research, but personally he failed to see how we could apply Gwilt in an ancient light case, or solve by his rule the problem of producing City offices to fetch high rentals with narrow light walls, to say nothing of countless other problems which daily presented themselves to architects. He trusted that Mr. Marks was in a minority of one in disparaging the efforts made by this Society to put the difficult and important subject of natural and artificial illumination on a practical basis.

Mr. Mackinney had drawn attention to an apparent discrepancy between the summer and winter readings of the Wimbledon Schools. He would like to mention that the summer readings were taken on a very variable day, and if all the rooms had shown the same difference between winter and summer the result would have been purely accidental. The important point was whether the measured ratios agreed.

Dr. Kerr's remarks as to variations in visual requirements under different circumstances were most useful. One of the doubtful pleasures of research in daylight problems was that as soon as one had unravelled some particularly knotty physical point one found an interesting series of physiological problems awaiting solution, and when these were determined there were generally a few psychological influences to take into account.

In conclusion, he congratulated the Society upon the valuable discussion which had taken place, and thanked the members and visitors for the reception which they had generously accorded to his paper. If any excuse were needed for it, he believed that Confucius had mentioned some thousands of years ago that true knowledge consisted of knowing how much we know and how much we don't know. The paper had entailed considerable hard work, but that was more than amply repaid by the interesting suggestions to which it had given rise, and the prospect of further valuable researches.

SOME QUERIES ON DAYLIGHT ILLUMINATION.

(*Continued from page* 43.)

IN our last issue (p. 33) we published a summary of replies to the series of queries on daylight illumination. Several additional replies have since been received, and for the convenience of readers we reproduce again the series of questions to which they refer.

Anyone interested is invited to send information on these points to the Hon. Secretary of the Society (MR. L. GASTER, 32, VICTORIA STREET, LONDON, S.W.).

(1) What measure would you suggest for the minimum actual illumination on the desk for reading in the schoolroom in full (midday) daylight ?

(2) What is the minimum intensity of daylight illumination on the worst-lighted desk in a schoolroom at which you consider that it becomes : (a) preferable, (b) essential to turn on the artificial light in the evening ?

(3) Do you consider a combination of daylight and artificial illumination to be. (a) satisfactory, or (b) inconvenient to vision ?

(4) Under what sky conditions or under what degree of sky brightness should the above minimum daylight illumination be obtained with a free horizon ?

(5) To what angle with the horizontal do you consider that surrounding buildings can be allowed to obstruct the sky hemisphere subtended at the window without materially affecting the light afforded by windows if the latter are of suitable width, and

(a) Subtend an angle of not less than 25° with the back desk,

(b) Subtend any lesser angle ?

(6) Is it desirable to specify that a certain vertical and horizontal angle of sky should be visible from all the desks in a room? What angles are necessary to ensure the minimum illumination under conditions of minimum sky brightness ?

(7) What are the recommendations for dimensions of schoolrooms in your country ? and what regulations are usual with regard to the window area of rooms of a certain size ? Do you consider it preferable to specify that the window glass (but not necessarily visible sky) should subtend a certain vertical and horizontal angle at the back of the room, and what angles would you suggest as desirable in order to obtain the minimum illumination under conditions of minimum sky brightness ?

(8) What is the best method of relating the illumination on the desk in the schoolroom with (a) the unrestricted illumination outdoors, (b) the sky brightness ? Do you think that such data constitute a practical method of comparing the access of daylight into various buildings ; and that they could be made the basis of a specification stating the size of windows and dimensions of schoolrooms ?

(9) What in your experience is the usual variation in daylight illumination met with respectively in the case of the worst and best-lighted desks in a schoolroom ?

(10) Are you in favour of unilateral lighting (windows on one side only) in a schoolroom ? Or do you consider additional windows in the other walls, or skylights (when practicable) also desirable ? In cases where bilateral lighting is unavoidable, do you consider that its effects can be mitigated by skylights or windows at a high angle ?

(11) Do you consider glazed partitions giving light from a well-lit room to one less well lit to be (a) a useful expedient, (b) preferable to a light coloured wall space ?

(12) Do you consider photometric tests in small models of buildings trustworthy as a means of determining the illumination to be derived from windows ; have you any records of such tests ?

(13) Is it desirable to recommend that the walls and ceilings in a room should have a certain minimum reflecting power ?

(14) Have you any other suggestions to make regarding the measurement of daylight illumination ?

SOME QUERIES ON DAYLIGHT ILLUMINATION.

ADDITIONAL REPLIES RECEIVED.

Prof. F. K. Richtmyer (Cornell University, Ithaca, U.S.A.) :—

(1) I know of no actual data beyond the customary ten metre-candle minimum limit. I would suggest that the minimum value would depend upon the age of the pupil; younger pupils requiring a better illumination than older ones, since they recognise words not as a whole, but by the individual letters.

(2) I know of no data answering this question.

(3) The combination of artificial and daylight illumination *ought* to be satisfactory, provided the artificial component be diffuse. The dissatisfaction that has been expressed relative to the combination of the two may be in part due to the fact that shadows will be apparently differently coloured. If there are, however, no sharp shadows this difference in colour would be minimised.

(4) and (5) I know of no data.

(6) I think it would be desirable to specify a certain vertical and horizontal angle of sky line, but I do not believe it is practicable in view of the fact that in many of our larger cities, schools must be located in places where it would be impossible to provide a minimum sky angle. I understand that prism glass is being very successfully used for illuminating schoolrooms under these conditions.

7. The consensus of opinion seems to be that schoolrooms should be approximately $30 \times 15\frac{1}{2} \times 28$ ft. for the maximum (fifty-six pupils and bilateral lighting), down to $30 \times 15\frac{1}{2} \times 21$ ft. for the minimum (forty pupils and unilateral lighting). In regard to the ratio of window area to floor space, there are various recommendations. A ratio of 1 to 6 or 1 to 5 is found in many places. A commission, several years ago, recommended a ratio of 1 to 4, and I understand that by using steel sash a model school-house has been constructed with a window ratio of 1 to 1·5 (bilateral lighting). It seems to be the practice to put windows from the back corner along the side up to the front row of desks, windows reaching from $2\frac{1}{2}$ or 3 ft. from the floor to the ceiling. It is also suggested that external objects which obstruct light entering a window should be located twice as far away as the height of the object.

(8) No suggestions.

(9) I do not know of a minimum value for the illumination that may be met in the worst-lighted schoolroom, but certain measurements indicate that the highest value may be as much as 2,500 metre-candles.

(10) Unilateral lighting for rooms less than 24 ft. wide. Bilateral for wider rooms. Windows in the rear of a room are to be avoided. Additional lighting should come from sky-lights.

(11) Glazed partitions are a poor expedient. Light coloured walls much preferable.

(12) No.

(13) Yes.

I trust that this data may be satisfactory to you. Some of it has been obtained by conference with Professor George M. Whipple, of Cornell University, who has made a special study of schoolroom conditions.

Prof. Max Gruber (Munich) :—

(1) Twenty-five metre-candles measured by direct method (equivalent to 10 m.-c. measured with red screen).

(2) Same as above.

(3) No inconvenience if shadows are avoided.

(4) Cannot be answered in terms of definite numerical data.

(5) Best method is to specify the solid angle (*Raumwinkel*).

(6—11) Fifty reduced square degrees min. for each desk. See also paper published in the *Gesundheits-Ingenieur*, 1904, No. 18, and abstracted in the last number of THE ILLUMINATING ENGINEER (p. 30).

(12) No. If a certain solid angle, to be subtended at each desk, is agreed upon, the necessary distance of other buildings, and the position, height, and breadth of the windows, &c., can all be calculated beforehand. (See paper referred to above.)

REVIEWS OF BOOKS.

A History of the Royal Society of Arts. By Sir Henry Trueman Wood. (John Murray, Albemarle Street, London, W. 15s. net.)

PROBABLY few people, even those who count themselves members of long standing, realise the vast scope of the work undertaken by the Royal Society of Arts since its foundation in 1754. Sir Henry Trueman Wood, in writing this history, has done a service both to the Society with which he has been so long and honourably connected and to the public.

He deals with a range of subjects that is almost bewildering. We learn of the Society's constant endeavours to encourage experiments in such matters as forestry, colonial enterprise, weaving, paper making, and lithography; its encouragement of music, art and technical education, and we realise for the first time how many are the movements of to-day which the Royal Society of Arts initiated, fostered, and finally allowed to develop an independent existence. It organised the first public exhibition of the works of artists, which led eventually to the formation of the Royal Academy; it was responsible for the first international exhibitions in this country; it gathered together the apparatus which formed the nucleus of the present scientific and engineering exhibits at the South Kensington Museum; and it was one of the very earliest pioneers in the subject of industrial hygiene and safety.

Similarly in 1882 the Society's building was one of the very first in London to be lighted by electricity, and as each illuminant came to the front it was in turn encouraged and exhibited.

In much of this work we see the first realisation of the field now being undertaken by the Illuminating Engineering Society, in whose house the Society has enjoyed the privilege of meeting from its commencement five years ago. For many years the Royal Society of Arts has provided its members with opportunities of widening their interests and acquiring new information. We feel sure that the scope of Sir Henry's work, which is written in a characteristically lucid and conscientious manner, will be of interest to a very wide circle of readers.

The International Review of Commerce and Industry. Edited by T. Swinborne Sheldrake. (Published by L. Upcott Gill and Son, Ltd., London. 2s. net.)

WE have before us the first two numbers of this Magazine, which is issued monthly. They contain a very varied series of articles on topics of the day. We note, for example, Prof. Ashley's article on "Commerce and the Universities," and contributions on "Oil Fuel," "Trade Routes as they will be affected by the Panama Canal," "The Insuperable Obstacles to a British Empire Trade Mark"—all subjects of considerable interest. The magazine should have a bright future before it.

ERRATA.

OUR attention has been drawn to what appears to be a clerical error in the article on "A New Method of Sealing Electrodes in the Quartz Tube Mercury Vapour Lamps" in the last number of the journal (p. 12). It should be made clear that the seals hitherto employed are made of special nickel steel known as "Invar."

We are also informed that the use of a solid anode for such lamps was investigated in this country about three years ago and actually embodied in one form of lamp put on the market about that date.

On page 32 of THE ILLUMINATING ENGINEER for January, 1914, for Dr. A. E. Nash, read *Dr. E. H. T. Nash* (Wimbledon).

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

SOME recent correspondence in the *Electrical World* deals with the **comparison of daylight and artificial light.** It is curious to see that the same subjects that have been prominent in this country are also being discussed across the Atlantic. It is evident that people, in considering the next improvements in artificial lighting, are turning to the study of daylight. One point discussed in a recent letter by CRAVATH is the supposed inconvenience of a mixture of natural and artificial light. He thinks the trouble is less than is supposed, and is usually met with when there is a marked change in the direction from which light comes in the two cases.

In another article Cravath points out the difficulty experienced by the eye in detecting small variations in brightness. It is, in short, a very bad photometer. By actual experience it was found that in streets a variation of 10 : 1 was indistinguishable to the eye. Cravath argues, therefore, that there is no need to aim at uniformity much within these limits. With indirect lighting indoors, where the shadows have such indefinite edges, the detectable variation in illumination would be much less.

Several articles deal with **colour.** Thus BASSETT JONES discusses the relative advantages of mixing coloured lights and mixing pigments in decoration. It is rather curious that the former method, which has distinct advantages, has been very, very little used by those aiming at spectacular and decorative effects.

M. LUCKIESH contributes some additional data on **Visual Acuity and Coloured Light** (*Elec. World*, Dec. 6th, 1913). He considers it is now well established that acuteness of vision is greater for monochromatic than for white light. Even by daylight it is possible to secure a distinct gain in visual acuity by putting on spectacles of yellow-green glass.

The method of estimating the **resemblance of illuminants to daylight** recently suggested by BLOCH is discussed by JASSE (*E.T.Z.*, Dec. 18th, 1913), who suggests another method of grouping results in terms of the red, green, and blue components in the light. He collects together Bloch's data, and also some additional results obtained in America, in tabular form, showing which illuminants come nearest to daylight. He also shows how the illuminants can be located within the Maxwell colour triangle. It is curious that while the results obtained in Germany and the United States agree *relatively* the actual percentages of coloured light all differ in one direction. The illuminants are placed in the same order, but the percentage of red is greater in the one case than the other. This seems explicable by the supposition that the quality of daylight taken as the standard in the two cases was not quite the same.

Among articles on photometry we may note that relating the experience of "M" with a **10-candle pentane lamp** (*G.W.*, Jan. 10th). He finds that a blister sometimes forms inside the rubber tube, thus impeding the free passage of vapour. It would be a good plan if some non-perishable material could be found to take the place of rubber.

In the *Zeitschrift für Beleuchtungswesen* (Oct. 30th, 1913) there is an article summarising the ground for believing that "absolute photometry" is impracticable. The author quotes the researches of Pauli on this point, and also some experiments by Fröhlich on the response of the retinæ of animals to light of various colours.

ELECTRIC LIGHTING.

P. S. MILLAR (*Elec. World*, Jan. 3rd) contributes an article summarising progress in electric lighting during 1913. The chief event is naturally the coming of **the half-watt lamp.** A study of the development of this lamp is also contributed by ZIEGENBERG (*Z.f.B.*, Oct. 30th, 1913).

W. HECHLER (*A.E.G. Zeitschr.*, Oct., 1913) describes the **lighting of a large factory with flame arc lamps.** Stress is laid on the fact that specially shaped reflectors can be fitted to these lamps according as they are used for street or factory lighting. The specific consumption in the case considered is given as 0·08 watt per lux per sq. metre of floor. W. R. MOTT (*Elec. World*, Dec. 13th, 1913) shows that the efficiency of flame arc lamps can be quite materially affected by the presence of small quantities of water-vapour within the globes. EBERT (*Z.f.B.*, Oct. 30th, 1913) describes the use of quartz tube mercury vapour lamps for advertisement lighting. A photograph is reproduced showing the effective use of such lamps round the top of a large building at the extremities of a series of columns.

W. BAYER (*Elec. Anz.*, Dec. 4th, 1913) describes the electric **lighting of a recent exhibition at Breslau.** No arc lamps were used, the general lighting in the grounds being by clusters of incandescent lamps under reflectors at the top of large, tall poles. A special attempt was made to light up the outsides of buildings. The main hall was arranged in a series of terraces, which facilitated its illumination by concealed lights wired on a special principle. Night photos are also given showing the picturesque appearance of the lighted colonnades.

GAS, OIL, ACETYLENE LIGHTING, &c.

One of the most interesting items has been the illustrated description of the lighting of the main offices of the Laclede Gas Co., U.S.A. The hall is lighted by chandeliers carrying a series of mantles in diffusing globes, and this general lighting is supplemented by an effective use of burners equipped with bowls of white glass, mounted round the pillars. The fittings are of special design. A reference to this installation appears elsewhere in this issue.

In a recent article in the *Journal of Gaslighting* some useful statistics are given for the gas-lighting of a number of American cities. W. D. WILCOX (*Gas Age*, Dec. 1st, 1913) deals with the street-lighting situation in Chicago.

"S." (*J.G.L.*, *G.W.*, Jan. 3rd) lays stress on the **value of well-designed shades and reflectors** to the gas industry, the importance of concentrating the light where it is needed, and the shielding the eyes from the direct rays. He remarks, however, "shoplighting is a law unto itself—the stronger the glare the better the lighting." This is surely not true of the best class of shoplighting.

Several interesting articles have been appearing in the German technical papers, notably that by AHRENS, on the use of gas in connection with **lights of navigation,** which has just terminated in the *Zeitschrift für Beleuchtungswesen.*

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Gas Lighting in Interiors (*J.G.L.*, Dec. 23).

Outdoor Lighting in the United States (*J.G.L.*, Dec. 30, 1913).

Tilley High-Pressure Gas Lamps (*J.G.L.*, Jan. 13).

CONTRACTIONS USED.

Elek. Anz.—*Elektrotechnischer Anzeiger.*
Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E.T.Z.—*Elektrotechnische Zeitschrift.*
J.f.G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
J.G.L.—*Journal of Gaslighting.*
G.W.—*Gas World.*
L.u.L.—*Licht und Lampe..*
Z.f.B.—*Zeitschrift für Beleuchtungswesen.*

HALF WATT OSRAM

DRAWN WIRE LAMPS.

The Lamp that will revolutionise street lighting and shop exterior lighting.

The latest triumph in the manufacture of High Candle-power OSRAMS.

PRICES:

50/65 volts.	300 watts	-	**30/-**	each
50/65 volts.	500 watts	-	**35/-**	,,
100/130 volts.	500 watts	-	**35/-**	,,
100/130 volts.	1000 watts	-	**50/-**	,,
200/260 volts.	1000 watts	-	**50/-**	,,
100/130 volts.	1500 watts	-	**60/-**	,,
200/260 volts.	1500 watts	-	**60/-**	,,

NEW LIST JUST PUBLISHED.

Detailed information of unequalled interest to the Electrical Industry, concerning this remarkable development in OSRAM DRAWN WIRE LAMPS, is contained in the new List, No. O.S. 1773. Copies may be had post free on application.

THE GENERAL ELECTRIC CO., LTD.,
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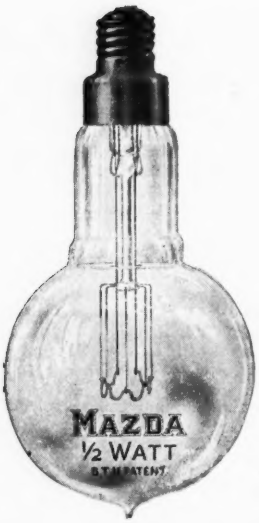

This illustration shows the typical arrangement of filament in a half-watt lamp. The compact spiral filament is mounted on long supports, so far from the cap that there is little obstruction of light, and the convection currents carry upwards all the particles emitted from the filament into the long neck. This is one of the factors which diminishes blackening in the bulb.

Half-watt lamps outside the Deutscher Künstler Theater in Berlin.

Typical half-watt lamp in iron case and reflector (A.E.G.) as used for the frontage of a Berlin Theatre.

A THEATRE FRONTAGE LIGHTED BY HALF-WATT LAMPS.

The illustration shows the frontage of the Deutscher Künstler Theater in Berlin, which has recently been illuminated by half-watt lamps. The adjacent block shows the nature of the fitting, the lamp being fitted direct into a metal reflector, no outer globe being used. It will be observed that the strong downward illumination brings out the statues in strong relief, and no doubt the half-watt lamps will be largely used for bracket lamps outside the frontages of buildings in future.

The night photograph of this installation was sent us by the **Allgemeine Elektricitäts-Gesellschaft** (Berlin).

TRADE TOPICS AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

THE ARRIVAL OF THE "HALF-WATT" LAMP.

BUT a short time ago we were referring to the "half-watt" lamp—the new tungsten lamp consuming only half a watt per c.p.—as a novelty likely to come before the public in the near future. A few specimens of the lamps were exhibited to the Press towards the end of last year.

Now announcements reach us from four firms, **The British Thomson Houston Co., Ltd.** ("Mazda"), **The Edison and Swan United Electric Co., Ltd.** ("Royal Ediswan"), **The General Electric Co., Ltd.** ("Osram"), and **Messrs. Siemens Bros. Dynamo Works, Ltd.** ("Wotan"), that the new lamps are commercially available.

The table shows the range of voltage and candle-power at present available.

Volts.	Watts.	Watts.	Price.
50—65	300	600	30/–
50—65	500	1,000	30/–
100—130	500	1,000	35/–
100—130	1,000	2,000	50/–
100—130	1,500	3,000	60/–
200—260	1,000	2,000	50/–
200—260	1,500	3,000	60/–

It will be recalled that in the half-watt lamp a stout spiral filament is attached to relatively long leading-in wires (with the result that the obstruction of light by the cap is small) and burns in an atmosphere of inert gases.

The new lamps are stated to consume only half a watt per candle, to give an average life of 800—1,000 hours, to have great strength of filament, and to give a decidedly "whiter" light than the ordinary tungsten lamp. It is pointed out that in future tungsten lamps giving from about 1—3,000 c.p. will be available —an immense range in intensity. Naturally for street and shop-lighting the fact of being able to secure such a high candle-power without any trimming or attention to the lamps will be a distinct advantage.

The design of fittings for the new lamps is being energetically taken up. The outdoor types available utilise a metal case and reflector, no outer globe being necessary, while for indoor work special diffusing globes and hemispheres are being developed. It is expected that the half-watt lamps will be specially suited for indirect and semi-indirect lighting.

WOTAN BATTERY LAMPS.

Messrs Siemens. Bros. Dynamo Works, Ltd., send us a copy of their new "Wotan" Battery Lamp list No. W.B.L. 2, which contains particulars of numerous types of "Wotan" Battery Lamps now obtainable.

It is of importance to note that arrangements have been made by the Committee of the Society of Motor Manufacturers and Traders to standardise lamps for automobile lighting, and the types of lamps listed are in accordance with the recommendations of that Committee as to the correct construction of lamps for automobile lighting.

A NOVEL AND DECORATIVE GAS-LIGHTED OFFICE.

THE illustration shows the main floor of the offices of the Laclede Gas Co., in St. Louis, U.S.A., recently described in the *Journal of Gaslighting*. When the installation in this office was carried out an attempt was made to obtain something out of the ordinary in decorative appearance. Special fittings were designed.

It will be seen that the main lighting comes from a series of chandeliers, each of which contains one large unit and eight smaller lamps around it; these are controlled from a distance by pneumatic switches. In addition, a distinctly novel form of bracket fitting has been mounted on the pillars. Each bracket employs two upright mantles mounted in 14-in. Persian etched bowls. The effect of the lighting is stated to be exceedingly soft and pleasing, and the illumination on the floor level is given as about 6 ft.-c. The design of these special fixtures, which are of solid brass throughout, was carried out by Mr. J. M. Coles, of the General Gas Light Co. Humphrey standard burners were used throughout. We understand that Mr. H. N. Clark, of 28, Brooke Street, Holborn, is the British representative for the Humphrey lamp and allied specialities.

EDISWAN CONTRACTS.

The Edison and Swan United Electric Light Co., Ltd., announce that they have secured important contracts for the supply of Royal Ediswan lamps to the Cunard Steamship Co., Messrs. Elder Dempster and Co., Ltd., and Cammell, Laird and Co., Ltd.

Other items of interest received include :—

The appointment to the British Admiralty as contractors for ampere gauges, from 15—500 amperes, for the following year.

The supply of Royal Ediswan drawn wire tungsten lamps to the London County Council, and to H.M.S. "Tiger."

The Edison and Swan Co. also announce that they have installed some of these lamps at their Showrooms at College Hill, and at their Queen Street Offices, for their customers to judge of the general appearance and effect of this class of lamp.

3

The
ILLUMINATING
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Edited by
LEON · GASTER

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EDITORIAL.

The Annual Dinner of the Illuminating Engineering Society.

The Annual Dinner of the Illuminating Engineering Society took place on Friday, Feb. 13th, and an account of the proceedings will be found on pages 139—146.

There was a good gathering of members, and the Society was again fortunate in having a number of distinguished guests.

It was particularly gratifying to note the presence of several of the earliest vice-presidents of the Society, including Sir Boverton Redwood, who proposed a vote of thanks to the President at the Inaugural Meeting in 1909; and Sir Henry Trueman Wood, who presided at the first Annual Dinner of the Society; both of whom alluded to the steady progress made during the years through which they have followed the work of the Society. As Sir Boverton Redwood remarked, during the first three years the Society was on its trial, but with the approaching end of the fifth year it might regard itself as being thoroughly established.

Another feature was the presence of Sir William Bennett, K.C.V.O., F.R.C.S., the President-Elect of the Society, in the chair. From its commencement the Society has endeavoured to secure the co-operation of those directly interested in various systems of lighting, and their practical appli-

cation. But it has always been felt that the activities of the Society should not be confined to the more purely technical aspects of illumination. It is right for specialists to discuss these matters together and come to an understanding, but something more is needed to impress their conclusions on the mind of the general public. In this direction the medical and architectural professions can help the Society, and the present moment is ripe for their co-operation. In particular, recent events have shown the great importance to the movement of the support of the medical profession, who are the trustees of the public health. In Sir William Bennett the Society has been fortunate in securing one of the most distinguished members of this profession, and we feel confident that his connection with the Society will add greatly to its prestige and will be the greatest possible assistance in stimulating public interest in the hygienic aspects of illumination.

The Lighting of Picture Galleries and Art Studios.

On pages 148–156 readers will find an account of the discussion on this subject which was opened by Prof. S. P. Thompson at the last meeting of the Illuminating Engineering Society. Prof. Thompson dealt with the subject with inimitable skill and charm, and the interest of the evening was added to by the presence of a number of distinguished artists.

It was soon made evident that the artists had their own ideas as to how pictures should be lighted, and that they entirely supported the lighting engineers' view that the actual sources of light should be concealed from the eyes, and the illumination distributed upon the pictures so as to make these the most prominent objects in the room. The method suggested by Mr. Joseph Pennell of accomplishing this object is of special interest. Logically, it is difficult to withstand the argument that the visitors to a gallery, while examining the brightly lighted pictures, should themselves be in a somewhat subdued light, on the same principle as is followed in the theatre.

It is highly probable that a distinction should be drawn between the best methods of lighting in a room devoted to the works of Old Masters, a collection of water colours, or a portrait gallery. This matter was touched upon in the contribution to the discussion by Mr. M. Luckiesh. He advocates the use of special coloured light according to the nature of the picture, and also points out that exceptionally fine effects can sometimes be obtained by arranging the inclination at which the light strikes the picture, so as to light more strongly certain portions of it.

We agree with the view expressed by Mr. David Murray, R.A., that a fine picture is a work of art under all conditions, and that it might often be undesirable for a lighting specialist who was not thoroughly conversant with the intentions of the artist to put his own interpretation on the meaning of the picture, and to light it accordingly.

But, on the other hand, it is also possible that, under the supervision of the artist a special form of lighting might display the picture to greater advantage. The artist has at his disposal a limited choice of pigments

and there are certain colours which it is by no means easy to imitate on canvas. By the use of certain pigments in conjunction with a special coloured light it might sometimes be possible to obtain an effect which could not be produced in the ordinary way.

But whatever view we take on this point, all must agree that the lighting of a picture is of vital importance. At present it must be owned that many galleries (when they *are* lighted by artificial means) are usually illuminated on a somewhat conventional plan, and that there is ample room for skill and ingenuity in re-designing the conditions in many modern galleries.

In the lighting of picture galleries our natural inclination is to consider *first* how to arrange the natural lighting, and then to study the artificial illumination in relation thereto. The subject is a complex but most interesting one. In the discussion Mr. A. P. Trotter suggested that a Joint Committee composed of artists and lighting engineers should be appointed to take up the illumination of art galleries, in the same way as has been done in the case of schools and libraries. We feel sure that the efforts of such a Committee would be repaid and we hope that this suggestion will be taken up.

The Colour of Illuminants and the Imitation of Daylight.

The above discussion revived the interesting question of producing "artificial daylight," which formed such a valuable paper at a previous meeting of the Society early in 1912. Since that time considerable progress has been made. Prof. Thompson was able to exhibit at the lecture tinted incandescent lamps designed to furnish a quality of light closely resembling daylight, and obtained from quite a number of lamp makers. Similar efforts have been made in connection with arc lamps; and it is also worthy of interest that Dr. Ives, of the United States, and Mr. Thorne Baker, in this country, have been experimenting with daylight screens for incandescent gas lamps. This point was also referred to at at the recent Congress held at Shepherd's Bush, when Prof. Vivian Lewes drew attention to the possibilities of high-pressure gas mantles for the production of artificial daylight.

One great advantage in artificial daylight of this kind is its constancy. On the other hand, daylight itself varies very considerably with the time of day and the season of the year.

It may be admitted that the so-called "artificial daylight" is not absolutely identical with natural illumination, with the result that there are certain tones which are not brought out with perfect accuracy. But there are nevertheless many fields of work in which the resemblance is quite sufficiently close to be very valuable.

Certain industries, for example, deal with a range of colours which appear substantially the same in the daytime and by the "artificial daylight." But even when it is known that the appearance of some delicate shades will not be absolutely correct, artificial daylight may still prove of service, provided these limitations are borne in mind. The whole subject is one that would repay further investigation.

The London Society and the Lighting of London.

Much useful work has already been accomplished by the Illuminating Engineering Society through co-operation with other bodies. It is therefore a pleasure to be able to add to the list of those bodies the London Society, before whom a paper by the writer on the Lighting of London was delivered on Feb. 10th.

The applications of light form so vast a field that the Illuminating Engineering Society cannot survey it all. From time to time there will be sections of the subject with which other societies are in a specially happy position to deal, and to whom the Society can suggest useful work. The London Society, for example, has been formed to study the general welfare of London and improvement of open spaces, parks, fine streets, &c., and to bring about co-operation with the various authorities dealing with such matters. This Society has now interested itself in the subject of London's Lighting, and we hope that it will continue to exert its very considerable influence in the directions suggested in this paper.

The imagination of the general public has been caught by the considerable changes which have been made in the lighting of London during recent years, and there is a general recognition that the appearance of a city by night depends to a very great extent on the way in which it is lighted. In fact, the progress in public lighting might well be taken as an indication of the state of civilisation and commercial prosperity attained by a city. Improved methods of locomotion and progress in artificial light are closely related, and the rapid growth of traffic in itself demands a better standard of illumination in the streets.

We will leave our readers to form their own opinion of the claim made in this paper for the control of the lighting by a central authority. It is pointed out that the present system—according to which the illumination of London is parcelled out among so many different authorities, each of which has many other duties to perform—is unlike that in any other city and has grave disadvantages. Lighting to-day has become a highly specialised matter for the expert. Naturally enough local authorities, however anxious they may be to keep abreast of the times, are not in a position to take advantage of the latest improvements in the same way as a body dealing exclusively with illumination could do.

A special claim may be made on behalf of the artistic aspects of public lighting. We feel sure that in the future the lighting of important public squares, memorials, and buildings of architectural distinction will be studied more fully. Lastly, we would like to make special reference to the lighting of the parks. It is surely an anomaly that these open spaces, which are so valuable to the health of the City, should be closed at dusk. If adequate artificial lighting were provided and the parks thrown open till a later hour, the public would make better use of them than at present.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(A REPORT PRESENTED AT THE SEVENTH ANNUAL CONVENTION OF THE AMERICAN ILLUMINATING ENGINEERING SOCIETY, PITTSBURGH, PA. (U.S.A.), SEPTEMBER 22-26TH, 1913.)

(*Concluded from p.* 64.)

Indirect and Semi-Indirect Lighting.

Indirect lighting, and its half-brother, semi-indirect lighting, are progressing steadily, and numerous installations of each are illustrated in the current technical journals. Manufacturers are almost daily producing new forms of fixtures of this type, some of them artistic in the extreme. One fixture for semi-indirect lighting has a space between the bowl and upper reflector enclosed with clear glass to keep out dirt, insects, &c. This has features of value, but its artistic merit is open to question.

As a relief from the present standard, though undesirable, method of lighting railway cars, it may be noted that certain express trains now running out of New York are now provided with indirect fixtures.[103]

Street Lighting.

The question of street lighting is attracting extraordinary attention. People are no longer satisfied with just enough light to see to move around safely, but are coming to a realising sense of the advertising and artistic values of ample light. White Ways are almost as common as towns themselves, and where the cities do not seem inclined to install them, the merchants put them in by private subscription. The open arc lamp is a back number, and in many cases the enclosed arc, once so universal, is giving place to magnetite or flaming arcs, or to clusters of tungsten lamps on ornamental poles. The old, severely plain iron or wooden pole is rapidly giving way to the artistic post, and there is a strong tendency to recognise the artistic as well as the utilitarian.

While much publicity is being secured to ornamental lighting, the majority of the business, however, has been connected with the ordinary street lighting, which is, in the electric field, practically working in the direction of the use of the luminous arc lamp, and the tungsten filament incandescent lamp. The increased standard of general street lighting has been largely accelerated by the reduced cost of light, and while it has taken on no distinctively new form, the standard of lumination intensity (not necessarily size of units) has been raised very considerably.

An interesting test was made in Switzerland to find the relative advantages of arc and metallic-filament incandescent electric lamps. Two streets

[103] *Electrical World*, April 26th, 1913.

of equal length were lighted with 10-ampere electric lamps and 500-candle incandescent lamps respectively. The choice between the two forms of lighting was left to 29 trolley car motormen. Of these 25 favoured the metallic-filament lamp on account of lessened glare and irritation to the eyes.[104] The mercury-vapour lamp has been suggested as a street lighting unit, but thus far its use for this purpose has been hardly more than a suggestion, although in one city lighted by a municipal electric plant, a group of merchants installed six quartz tube lamps to show by contrast the poor character of the general street lighting.

During a "street show" in one of our large cities, ornamental pillars each carrying three electric light globes were erected. Panels in these columns were made transparent by making them of wire netting and coating them with varnish of various colours, giving the effect, when lighted from the inside, of art glass.[105]

In the ornamental lighting system, it is frequently desirable to turn off the lamps without affecting the rest of the circuit. This is done in at least three towns by various systems of pilot wires and magnet switches centering at the central station or other convenient point.[106], [107], [108] In this connection may be noted a method of controlling from the central station switches on a network by superimposing a ripple on the regular voltage.[109] In another town a switchboard has been placed in the office of the chief of police so that in case of burglary or fire alarm after the regular time of shutting off, the ornamental system of street lighting may be turned on.[110]

An unfortunate dispute has arisen in one of the large cities of England over the relative merits of high pressure gas and flaming arc lamps. Two streets were lighted by the rival illuminants and experts representing each of the industries made illumination measurements and prepared reports. The tests were entirely in favour of the electric lamps, but the fact was brought out that the gas lamps were improperly adjusted and installed, so that no conclusions could be drawn as to the relative merits of the two systems. The whole affair caused much argument and a good deal of acrimonious discussion on the part of the advocates of the two systems.[111], [112]

Gas street lighting has made great strides in both England and Continental Europe, where high pressure lighting is in great favour. Automatic lighting of gas lamps is also making rapid progress on the other side of the Atlantic, the lamps in a large number of towns being equipped with these appliances. Two systems of automatic lighters are in extensive use, one being operated by a momentary addition to the street main pressure and the other by means of a clock arrangement on each post so that the lamps operate individually and independently. Highly encouraging reports as to the satisfactory and economical working of these systems have been made.

In this country street lighting by gas, while making steady progress, has not experienced the rapid growth that is so marked abroad. Automatic lighting has not as yet obtained a foothold here, and except for two minor installations, there is no high-pressure street lighting. Another difference between European and American practise is that abroad inverted burners are becoming the universal practise, while here, except for a two-mantle 150 candle-power lamp, the inverted burner is not used.

Ornamental street lighting by gas is spreading, a number of prominent installations having been made.

It may be of interest to note that one of our public utility commissions, which had been investigating the street lighting in a large city of the State, recommended that the city employ an illuminating engineer, to be retained permanently if possible, for the purpose of selecting

[104] *Electrical World*, April 26th, 1913.
[105] *Electrical World*, October 12th, 1912.
[106] *Electrical World*, November 30th, 1912.
[107] *Electrical World*, September 7th, 1912.
[108] *Electrical World*, September 14th, 1912.
[109] *Electrician*, February 14th, 1913.
[110] *Electrical World*, October 12th, 1912.
[111] *Journal of Gas Lighting*, October 5th, 1912.
[112] *Electrician*, March 7th and 14th, 1913.

the type of lamps to be used and to fix their location.[113]

Increased interest in street lighting does not seem to be unusual, however, as a recent item in a French technical journal contains the statement that in that country, out of 10,000 villages or communes of more than 1,000 inhabitants, 6,000 are without public lighting.[114]

Fixtures, Globes and Reflectors.

Architects and decorators are realising more and more the importance of artistic and appropriate gas and electric lighting fixtures, and new designs adapted to all conditions are daily appearing on the market. One type that is especially popular just now is the "shower" chandelier, and designs of great beauty have been brought out. Another new design is an indirect lighting portable which may be used as an ornamental table light.[115] Still another fixture designed to give a strong concentrated light for fine work consists of a small reflector socket carrying a tungsten lamp and welded to substantial brass tube bent so as to fit closely the body of the machine in connection with which it is to be used. This tube is securely fastened to the machine and becomes practically part of it.[116]

A novel fixture has been installed in the rotunda of one of our State buildings, and is probably the largest chandelier ever built. The fixture body is over sixteen feet high and is suspended by a chain seventy-two feet long, consisting of twelve-foot links containing special tubular tungsten lamps to give the effect of a string of light, the joints in the chain being provided with ball lamps in decorative design. The fixture itself is finished in composition silver leaf. In some of the reading rooms of the same building indirect lighting has been used with the bottoms of the basins made of pink Georgia marble, thus producing very beautiful effects. The general illumination of these rooms is low, and so each table is provided with reading lights designed by actually placing an individual at the table with a book and adjusting the lamp for his comfort.

In another installation in an office building an attempt was made to reproduce artificial daylight through a false skylight matching the colour received through an actual skylight in an adjoining room. The lighting is so arranged that at night, when artificial light is used, the colour of the illumination will be adjusted to match the artificial lighting.

In connection with the use of marble for diffusing material noted above, it is reported that patents have been taken out in Germany for using marble instead of glass. Marble is planed down until it became translucent and different intensities of light were shown from behind. The effect obtained was that the illumination was hardly distinguishable from daylight, and it was difficult to realise that the room was artificially lighted.[117]

Under this head might be mentioned efforts recently made to increase the brilliancy of moving pictures. The available sources of light having about reached the limit of their intensity, the reflecting power of the screens is now receiving attention. The early muslin screens were replaced with canvas coated with a layer of white; ground glass, which was next tried, was found too fragile, and was in turn replaced by a fabric coated with aluminum powder giving a screen presenting a silvery surface of great uniformity. The new screen is 3.7 times as luminous as the muslin.[118]

An investigator conducted a series of tests to determine the distribution of light in an ordinary room. Under the conditions of the test it was found that the light was strongest in the upper and lower part of the room and less intense throughout the middle portion. Working on this idea, a translucent screen was made in the form of a vertical half cylinder placed close to the wall; between it and the wall was set the light source. Measurement of the light distribution under these conditions showed

[113] *Electrical World*, January 18th, 1913.
[114] *L'Electricien*, January 11th, 1913.
[115] *Electrical Review* and *West. Elect.*, March 1st, 1913.
[116] *Electrical World*, November 2nd, 1912.
[117] *Good Lighting*, January, 1913.
[118] *Good Lighting*, January, 1913.

that it was almost identical with that obtained from daylight.[119]

About the first of last year a screen was brought out which filtered the rays of the electric arc light in such a proportion that those rays passing through it formed a true daylight colour. This was followed a short time ago by a similar screen for the incandescent gas lamp. The resulting light is a perfect match for average daylight, and by it colours may be judged with perfect accuracy.[120]

Physics.

Previous determinations of the constant of the Stefan-Boltzmann law of radiation vary from 5.3 to 6.5. During the past year, two independent investigations were made from which new figures for the constant were derived.[121, 122]

Another investigator describes experiments showing the deviation from Lambert's cosine law of tungsten and carbon at glowing temperatures. It was found that the brightness of tungsten, beginning with normal emission, increases with the angle of emission, reaches a maximum at about 75°, and for larger angles diminished rapidly. The brightness of carbon, beginning with normal emission, decreases with increasing angle of emission, the rate of decrease increasing with the angle. The relative brightness variations for tungsten at the higher of the two temperatures chosen are about 20 or 25 per cent. greater than the corresponding variations for the lower temperature. No definite change was found for carbon.[123]

An experimental lecture was delivered late last spring before a European society on the relations between spectral analysis and the electronic theory. The fundamental point was that what oscillates in light is nothing but electrons. The lecturer also discussed optical resonance as deduced from the theory of electrons and the Zeeman phenomenon.[124]

Legislation.

An appreciation of the importance of proper illumination is growing on the legislative bodies of different countries, and investigations are being held and laws passed governing particularly the lighting of factories and workshops. In Holland, the law specifies that the employment of women and young children is forbidden in works in which artificial light is normally required between 9 a.m. and 3 p.m. An illumination of 1½ foot-candles is specified as the minimum for certain processes exceptionally trying to the eyes, and a minimum of one foot-candle in less exacting occupations.[125]

In England, a special committee has been appointed by the Home Secretary to inquire into conditions necessary for adequate and suitable lighting of factories, and in France the question has been under discussion for about two years.[126, 127]

In our own country the New York State Factory Investigating Commission has been studying the lighting of workshops for two years,[128, 129, 130] and a bill has been drafted with the aid of a committee from this Society for its regulation. The Industrial Commission of Wisconsin last January issued its general order on sanitation which included ventilation and shop lighting. This order provides for daylight illumination and specifies the minimum illumination under different conditions.[131]

Photography in Illuminating Engineering.

An interesting lecture was delivered not long ago illustrating the value of photography in illuminating engineering. The speaker laid stress on the difficulty of obtaining good photographs by artificial light, and said that there was little information available as to what the exposure ought to be or how to allow for the actinic values of the different kinds of light. The two essentials in a good photograph of an installation are that the room shall appear exactly as it really is by artificial light, and that the

[119] TRANSACTIONS Illuminating Engineering Society, June, 1913.
[120] *Lighting Journal*, May, 1913.
[121] *Electrician*, December 20th, 1912.
[122] *Deutsch Phys. Gesell.*, November 15th, 1912.
[123] *Astrophys.*, December, 1912.
[124] *Elek. Zeit.*, April 23rd, 1913.
[125] *Iron Age*, August 17th, 1912.
[126] *Journal of Gas Lighting*, January 28th, 1913.
[127] *Electrician*, January 24th, 1913.
[128] *Gas World*, December 14th, 1912.
[129] *Journal of Gas Lighting*, December 17th, 1912.
[130] *Electrical World*, December 28th, 1912.
[131] *Gas Age*, March 15th, 1913.

positions and natural appearance of the fixtures shall be shown without halation or distortion. The lecturer believes that the ideal way to preserve a good record of lighting installations is to have a really good photograph showing the actual installation as it appeared to the eye and also data on intensity of illumination.[132]

In another lecture on photography, by invisible light, the speaker said that the longest infra-red rays thus far measured (those of the quartz) have a wave-length of 0.3 mm., while the shortest electrical waves observed are 2 mm. in length, indicating a brief undiscovered gap between the two sets of phenomena. The lecturer showed ultra-violet photographs of the invisible electronic discharge which proceeds from the ordinary electric arc and not detectible to the eye. A current of air diminishes the intensity of this discharge within its own range, but does not affect the streamers beyond. The ultra-violet photographs presented were most interesting in showing the diffusion of the ultra-violet shadows even in full sunshine. Ordinary glass is practically opaque to light of this short wave-length, while the pigment "Chinese white" appears black under its illumination. The lecturer's lunar photographs also show hitherto invisible patches of heterogeneous material near one of the craters indicating strongly the possibility of sulphur deposits and so contributing to the evidence of their volcanic origin. The infra-red landscape views were remarkable for their black skies and strong shadows and for the snowy whiteness with which the green foliage appears, owing to the deep-red component of its chlorophyl colouring matters.[133]

Illumination Measurements and Calculations.

Some study has been put upon methods of determining and calculating illumination under various conditions, and a number of ways of shortening and simplifying existing means have been put forth. One writer suggests that if a curve be plotted in which the y-axis, corresponding to the relation of the intensities of the lights, be divided to a logarithmic scale, and the x-axis, corresponding to the distance from one of the lights to the screen, be divided to a natural scale, the resulting curve will have a much more useful character than if drawn on ordinary graph paper.[134]

A method has been worked out for determining the illumination at any point on a flat surface illuminated by a source above it. The method consists in dividing up the surface into areas each corresponding with a unit solid angle. By means of the formulae and tables given, the illumination can be calculated more exactly than by the approximate methods generally employed.[135]

One author criticises the present method of laying out the light distribution curves of any source, and recommends an illumination distribution curve in which the lengths of the polar ordinates are proportional to the product of the intensities into the areas of the zones in which the rays are taken. The same writer calls attention to the fact that an error is introduced in the illumination measurements by neglecting the more or less efficient utilization of the reflected light according to the angle of emission from the light source.[136]

Respectfully submitted,

F. N. MORTON, *Chairman*,
F. E. CADY,
E. L. ELLIOTT,
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FRANK E. WALLIS,
W. R. BURROWS,
DR. F. PARK LEWIS,
T. J. LITLE,
BASSETT JONES, JR.

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[132] *Illuminating Engineer* (London), December, 1912.
[133] *Electrical World*, February 8th, 1913.
[134] *Archiv. für Elektrotechnik*, 1, 1912.
[135] *Elektrotech. Zeitsch.*, December 19th, 1912.
[136] *Progressive Age*, December 2nd, 1912.

STATISTICS ON THE LIGHTING ART.

PRESIDENTIAL ADDRESS DELIVERED BY MR. P. S. MILLAR BEFORE THE AMERICAN ILLUMINATING ENGINEERING SOCIETY.

IN his address Mr. Millar made a survey of modern lighting conditions, showing how such factors as the intensity of illumination, direction of light, colour, steadiness, &c., are now being taken into account. In the course of his address he gives the results of a number of inquiries that have been sent out to manufacturers dealing with such subjects. The country was divided into areas of approximately 1,000,000 population each, and, so far as practicable, lists of questions were sent to possible sources of information in each section of one million population. In all there were 128 questions, many being duplicates of questions appearing on other sheets. Approximately, 1,750 lists of questions were issued.

It is interesting to observe that the standard of illumination has increased very considerably during recent years. Data received from manufacturers of electric incandescent lamps shows that the average candle-power of lamps supplied has altered in accordance with the following table in the column.

Year.	Approx. average candle-power of all incandescent lamps sold.	Year.	Approx. average candle-power of all incandescent lamps sold.
1906 ..	18	1910 ..	25
1907 ..	19	1911 ..	26
1908 ..	21	1912 ..	29
1909 ..	23	1913 (est'm't'd)	32

In many cases increase of illumination in one direction has made necessary a corresponding development in another. For example, the "white way" system of lighting has made it necessary for shop windows to increase their illumination substantially. Otherwise the street would have a greater brightness than the windows which would naturally prejudice their value as an advertisement.

It is only quite recently that any systematic records of the intensity of illumination have been kept. It appears however, that a tolerably complete record has been kept of the lighting of railway cars; and that in cases where the illumination has not been measured a knowledge of the type of lamp employed enables one to calculate what the approximate value must have been. Mr. Millar presents the following record:—

DAY COACH LIGHTING.

Installed during	Description of Illuminants.	Average Horizontal Foot-candles 30 ins. above floor.
1850–1875 ..	Oil lamps—	
	2 wicks feeding one flame	0·5
	Annular wick	1·0
1875–1900 ..	Pintsch gas—	
	4 fish-tail flames	1·5
	4 mantle cluster	1·65
1880–1900 ..	Carburetted gasoline—	
	Centre draught	1·3
1900 to date	Electric—	
	50-watt opal-tip lamps and flat reflectors ..	1·4
	50-watt clear lamps and satin finish bowl reflectors	3·0

In the same way the author tabulates a few values which are put forward as representatives of the conditions of illumination in modern streets, shops, factories, &c., though naturally such figures are put forward with some reserve :—

TYPICAL INTENSITIES OF ARTIFICIAL ILLUMINATION.

Class.	As Measured through.	Foo-candles.		
		Average	Usual.	Range.
Street Lighting : Principal streets in cities	Horizontal plane of street surface	0·4	0·25	2·0
Important side streets	Horizontal plane of street surface	0·15	0·1	0·25
Residence streets ..	Horizontal plane of street surface	0·04	0·01	0·10
Store lighting ..	Horizontal plane 30 in. above floor	4	2·6	—
Show-window lighting	Plane of trim	18	12·25	—
Factory lighting ..	Horizontal plane 30 in. above floor	3	2·6	—
Office lighting ..	Horizontal plane 30 in. above floor	3	2·4	—
Residence lighting	Horizontal plane 30 in. above floor	1·5	1·3	—
Railway car lighting	Horizontal plane 30 in. above floor	2	1·3	—

Mr. Millar estimates that only 15—25 per cent. of stores and offices in America employ illuminants without auxiliaries of some kind ; in quite 65 per cent. of all installations some device is used to direct the light where it is most needed.

STATISTICS ON COST OF LIGHTING.

Small wage-earners' homes : ratio of cost of lighting to total income, 1 per cent.

Well-conducted large manufacturing establishments, which are well lighted with modern illuminants : ratio of cost of artificial lighting to total cost of output, exclusive of selling expenses, one-third to one-half of 1 per cent.

Large retail mercantile establishments : ratio of total lighting cost to total sales, probably less than 1 per cent.

Small stores : ratio of total lighting cost to total sales, 2 per cent.

Modern loft buildings : 1 to 2 per cent.

Street lighting appropriations by municipalities are of the order of 60 cents to $1 per inhabitant per year.

In comparison with the benefits conferred in added commercial advantages and extended opportunities in education, social life and recreation, the cost of artificial lighting is remarkably low.

THE LIGHTING OF LONDON.

A PAPER on the above subject was read by Mr. Leon Gaster at a meeting of the London Society, held at the Royal United Services Institution, Whitehall, S.W., on February 10th. Col. R. E. Crompton, C.B., Consulting Engineer to the Road Board, was in the chair. In the following pages we print a summary of this paper.

Mr. A. P. TROTTER, in opening the discussion, complimented Mr. Gaster on his work in connection with the Illuminating Engineering Society. His own experience went back to the early days when he first met Colonel Crompton at the Paris Exhibition in 1881. Sir Wm. Preece was among the first to recognise that it was *the illumination* of the streets that was required irrespective of whether few or many lamps were employed, and to invent an instrument for measuring illumination.

Mr. Trotter then referred to the recent work of the Joint Committee on the Street Lighting Specification and described how a judgment of the lighting of streets, classified in terms of the minimum illumination, had been found to be in exact agreement with the impressions of a number of expert borough engineers.

Mr. FRANK BAILEY (City of London Electric Supply Co.) remarked that the paper had shown, most graphically, the improvement in public lighting during recent years. The City of London had set a good example to the rest of the Metropolis, but there were still many streets insufficiently lighted. It was also necessary to use modern illuminants wisely, since their high intrinsic brilliancy might become a danger.

In conclusion, Mr. Bailey expressed his regret that some of the beautiful statues in London and also the stained glass windows in some of the churches were not illuminated at night.

Mr. CHAS. A. BAKER (Electrical Engineer to the L.C.C.) said that in the main, the street lighting in London to-day was good and it improved from time to time as new and more efficient illuminants were introduced. The problem was one of £ s. d. Some local authorities had so many other items to consider besides the lighting, that they could not provide the same illumination as in more wealthy districts. With regard to the "grading" of the lighting in streets, he agreed that special illumination would often be necessary at street corners and busy crossings.

The CHAIRMAN, after complimenting Mr. Gaster on his paper, agreed that the lighting of the streets could be standardised with great advantage, and that the placing of very bright sources outside shops at a low level should be discouraged. But he was not in favour of London being lighted from one central source of supply in view of the immense area to be covered. The various districts should be lighted separately so that any possible failure would not affect the whole city, but only one portion. However, he agreed that eight or ten centres of supply would be sufficient and that thirty were no doubt too many.

It should be recognised that the Borough Councils, although met by difficulties, had not done their work badly. Taken as a whole the lighting of London was satisfactory, and he was proud of what had been done by his City in that respect.

Mr. LEON GASTER, in reply, expressed his appreciation of the kind remarks on the work of the Illuminating Engineering Society. He wished to make it clear to the Chairman that his proposal for the central control of the lighting of London referred to the treatment of the illumination rather than to the electrical supply.

As regards the Borough Councils, he did not mean to infer that they did not do their best in the circumstances. But the Councils had so many other duties to perform that they naturally could not make a special study of illumination; and therefore the lighting of London would be still done better if it were handled scientifically by a central authority. He hoped the Chairman would agree with him that experts on illumination, who maintained an impartial attitude with regard to the various illuminants, might be of great assistance to the Borough Councils.

Good lighting was an asset to any city. He was glad to think that London occupied a high position in this respect, but in his opinion something better still might be accomplished.

A cordial vote of thanks to Mr. Gaster for his paper terminated the proceedings.

THE LIGHTING OF LONDON.

By Leon Gaster.

Summary of paper read before the London Society, on Tuesday the 10th February, 1914.

Illumination, alike in the home and in the streets of a great city, exercises a most potent influence on the health, social conditions, and general welfare of its people. It is closely connected with the planning of the streets and buildings, and with many problems that come under the supervision of municipal authorities. Public lighting, therefore, is a subject which should be of considerable interest to the London Society.

In this paper it was thought advisable to avoid detailed reference to many technical matters which have been ably dealt with in recent papers by Messrs. A. P. Trotter,[1] Haydn T. Harrison,[2] J. Abady,[3] S. L. Pearce and H. A. Ratcliffe,[4] and others, before various societies.

Similarly, only casual reference is made to another matter which has had a great influence on London's lighting, namely, the way a city is governed; this subject will be discussed by the London Society later on.

Public Lighting in Days gone by.

Nowadays quite a sharp demarcation exists between public and private lighting. But in the olden days this was not the case. In the Middle Ages any party venturing into the streets by night was preceded by a retainer carrying a flambeau, and the "link-boy" with his torch is seen at work in many prints of a much later date.[5] There are still houses in London whose doorways are ornamented by iron funnels into which the servants accompanying the venturous party plunged their torches on their safe return home.

Each individual party, in short, did its best to provide sufficient light to take the place of public illumination. In those days the streets were infested with gangs of rowdies and were in a most unsafe condition, and the history of the last few hundred years shows how improved street illumination has gradually brought about the present state of comparative security.

The first attempt at regular street lighting in London appears to date from 1415, when Sir Henry Burton,[6] then Lord Mayor, ordered all householders to hang out lanterns in the evenings between All Hallows and Candlemas, a practice which they were obliged to follow for upwards of three hundred years. At one period every householder whose house fronted a street and was rented at £10 per annum was obliged, under a penalty of one shilling, to hang out a light from six to eleven on every dark night between September 29th and March 25th. It was not until 1736 that lighting was taken out of private hands and the organised service passed to the hands of the Common Council of Ward. Eventually the business of lighting seems to have fallen into the hands of the Commissioners of Sewers.[7] Indeed, it is interesting to notice that the report of the late Sir William Preece on the Lighting of Some Streets in the City of London in 1883 came before the Select Committee of this body. In fact, the idea of the lighting and cleansing of the streets seems to have often been connected together, and in France, La Reynie, the celebrated Lieutenant of Police in the reign of Louis XIV., adopted as his motto:—"*Netteté, Clarté et Sûreté.*" Under his supervision remarkable improvements were made in the year 1666,[8] and the

[1] Standard clauses for inclusion in a specification on Street Lighting, *Illum. Eng.* (Lond.), May, 1913.

[2] Street Lighting by Modern Electric Lamps. Paper read before the Institution of Electrical Engineers, November 24th, 1910.

[3] Public Lighting from a Municipal Standpoint. Paper read before the Institution of Gas Engineers, June, 1910.

[4] Recent Developments in the Street Lighting of Manchester, *Journ. Inst. of Elec. Engineers*, Vol. 50, p. 596, 1913.

[5] See lecture by W. J. Liberty before the Illuminating Engineering Society, *Illum. Eng.* (Lond.), April, 1913.

[6] *Illum. Eng.* (Lond.), Vol. II., 1909, p. 87.

[7] *Illum. Eng.*, Vol. II., 1909, p. 274.

[8] Defrance, *Histoire de l'Eclairage des Rues de Paris.*

King ordered a medal to be struck in honour of the improved illumination.

During all these years lighting was carried out exclusively by oil lamps. The light furnished by these must have been exceedingly feeble in comparison with the illuminants of present times, and it is interesting to notice how this stimulated ingenuity in making the very best use of the small means of light available. For example, we note that about the year 1763, a certain M. Le Fevre[9] conceived an idea of lighting the whole of London by means of a powerful lamp placed inside parabolic reflectors and mounted at the top of a high tower. Many of the researches, however, had a truly scientific basis. In a booklet issued by J. G. J. B. Count Thivelle in the year 1800, there is a reference to the inefficient character of the oil lamps in bull's-eye lanterns placed on Westminster Bridge. He described quite a number of ingenious devices "employing reflection and refraction" for directing the rays of light on the surface of the street. Commenting on the street lamps of those days he remarks: "The result is that light is thrown upon the eyes of the passengers without illuminating the streets, since no part of the pavement receives any benefit from the effect of the light. . . . The utmost degree of perfection would be attained if the whole pavement and streets could be illuminated without our perceiving from whence the light proceeds."

The great chemist Lavoisier, who was responsible for the design of many of the improved street lamps using reflectors in Paris, was struck by the same defect in the lighting of those days. The acute comment of these two savants that the function of a street lamp is to illuminate the pavement and not to shine in the eyes of passers-by, might be taken to heart by many of those responsible for street lighting to-day.

It is difficult to say with certainty exactly what light was yielded by these old lamps, but it is stated that they had usually an oil flame about half an inch wide and that they were placed about 40 ft. apart.

[9] *The Gentleman's Magazine*, Vol. 33, 1763.

The Coming of Gas Lighting.

This was the state of things when gas lighting came to be introduced about the beginning of the last century. From the records of those times we find some evidence as to the order of illumination provided. For example, in Pall Mall, which was first lighted by gas about 1807, the gas burners introduced were stated to give an illuminating power equal to about 3 c.p.; and even this was considered a tremendous improvement upon what had been provided before. For example, in a report issued at that period it was stated that the new lamps were equivalent to eighteen of the old parish oil lamps; according to this rating the old oil lamps can only have furnished about one-sixth of a candle-power.[10] At the present day Pall Mall is lighted by high-pressure gas lamps estimated to give several thousand candle-power.

Through the courtesy of the South Metropolitan Gas Co. I have obtained some particulars of the history of lighting in their area. It appears that in the period 1860—1878, iron-tip flat-flame burners consuming about 5—6 cub. ft. of gas per hour and yielding approximately 12 c.p. were in general use; and this procedure was probably characteristic of the whole of London. In 1878 Steatite burners giving about 15 c.p. were substituted, and at a later period (1895) two burners, or special Sugg burners consuming 10 cub. ft. per hour and yielding perhaps 30—40 c.p., were sometimes used on refuges and in important positions. It was not until the commencement of the twentieth century that incandescent burners began to be used, the first borough to install these being Camberwell, in 1899. These were No. 4 burners consuming about 4½ cub. ft. per hour and giving 50 c.p.; for side streets burners giving about 20 c.p. were used. In 1900 incandescent burners were introduced into Lambeth, and in other districts shortly after. At the present day inverted burners are very generally used throughout London, and many streets lighted by low-pressure contain two burners, each consuming about 4 cub. ft. and yielding together about 200 c.p.

[10] See an old volume in the London Institution Library. *Illum. Eng.*, Vol. III., 1910, p. 18.

Mr. Talbot, the Superintendent of Outdoor Lighting to the South Metropolitan Gas Co., informs me that the comparative conditions of public lighting in the district of that company in 1882 and at the end of 1913 are approximately as follows :—

some areas where not so much progress has been made; 1882 is the date at which the amalgamation of the various companies into the South Metropolitan Gas Co. were practically complete. It is also the date at which the competition of electricity began to make itself felt.

PUBLIC LIGHTING IN THE SOUTH METROPOLITAN GAS CO.'S DISTRICT, 1882 TO 1913.

Date.	No. of Burners.	Total candle-power (estimated).
1882	14,014 (flat-flame)	175,175
1913	24,560 (incandescent)	1,410,250

A calculation shows that, in spite of the candle-power being increased *about eight times*, the cost to-day would presumably not exceed that in 1882. The date 1882 has been selected as giving an idea of the enormous change that has come over public lighting in the last thirty years. No doubt in many streets the increase is far greater, and of course there are also

It will be observed also that in the South Metropolitan Gas Co.'s district the lighting is carried out mainly by low-pressure (2—3″). But if we were to take such a street as Whitehall, using high-pressure gas lamps and lamps giving several thousand candle-power, the difference would be still greater. We might summarise the condition of public lighting by

FIG. 1.—"Parade" Gas Lighting : Lewisham High Road.

gas from the oil-lamps period up to the present day somewhat as follows :—

progress in illuminants has been very great. The introduction of high-pressure

Nature of Illuminant.	Period.	Public lamps.		
		Gas consumed cub. ft. per hr.	C.P.	C.P. per cub. ft.
Oil lamps	up to 1800	—	$\frac{1}{8}$—1(?)	—
Very early gas burners	about 1810	3(?)	3	1(?)
Iron-tip gas burners	1860—1878	5—6	12	$2\frac{1}{2}$
Steatite burners	1878—	5—6	15	3
Special Bray and Sugg burners	1895	10	30—40	5
Incandescent upright (early type) low pressure	1899	$4\frac{1}{2}$	50	11
Incandescent inverted low pressure ..	1908—1914	$2\frac{1}{2}$—8	35—200	25
Incandescent inverted high pressure..	1914	40—70	2000—4,000	50—60

An important point to notice in this table is that the rate of progress has become increasingly rapid during the last few years. Previous to 1882 few radical improvements were made in street lighting, which remained substantially the same many years. But since 1900 the gas has added immensely to the brilliancy of the lighting in many of our main streets. I am informed that during the last ten years the total candle-power of the lamps in the area of the Gas Light and Coke Co. has increased from 1,900,000 to 4,300,000—an increase of over 125 per

FIG. 2.—High-Pressure Gas Lights outside the Brixton Town Hall.

cent. In this connection I might refer to an excellent paper read before the Illuminating Engineering Society in 1910[11] by Mr. F. W. Goodenough, who has been so closely associated with the great progress of high-pressure gas in the Gas Light and Coke Co.'s area.

Electric Lighting.

The use of electricity for public lighting in London seems to date from about the year 1878, when several experimental installations were attempted. The Chairman of to-night, Colonel Crompton, was associated with some of the very earliest pioneering work in this direction. In 1877 he lighted his own factory by electricity, and by 1878 he was already constructing electric arc lamps of his own invention. In 1881 he was responsible for lighting several railway stations by electricity, and about the same year the Royal Courts of Justice were illuminated by incandescent lamps—one of the first large installations of this kind in England.

As is well known, some experiments with electric Jablochkoff arc lamps were carried out on the Embankment about the same time. Through the courtesy of Mr. Chas. A. Baker, the electrical engineer to the London County Council, I have had access to some reports presented to the Metropolitan Board of Works in 1879.[12] It appears that the gas lamps of that date gave only about 2,720 c.p. The arc lamps were stated to give about 265 c.p. each (with frosted globes probably absorbing between 50—60 per cent. of the light of the arc)—a light which to the people of those days appeared of enormous brilliancy, and by their use it was estimated that the candle-power on the Embankment would be raised to about 13,000 c.p.

But at the present time, when the Embankment is lighted mainly by modern flame arc lamps, the total candle-power of the lamps employed is estimated to be nearly 200,000 c.p.—*i.e.*, about 75 times the value of the gas lamps originally used about 32 years ago (1882). Yet the cost is probably only about three times as great and not greatly different from that estimated for the 13,000 c.p. provided by the old Jablockkoff arcs.

These data are collected in tabular form.

A very interesting glimpse of the early state of electric lighting in the City of London is also gained from a report presented by the late Sir William Preece to the Electric Lighting Committee of the Commissioners of Sewers in 1883.

In many respects Sir William was remarkably ahead of his time. In his report he not only gives the candle-power of the lamps but calculated the actual illumination on the street surface. He also referred to the possibilities of the "dioptic globes," invented by Mr. A. P. Trotter about that time, as a means of distributing the light in the streets to better advantage. Here we see an instance of how far Mr. Trotter's connection with illumination goes back; in fact he was one of the pioneers of the subject in this country.

Embankment Lighting (Westminster to Blackfriars Bridge, including Westminster and Waterloo Bridges), 1882—1914.

Date.	Nature and No. of Lamps.	Candle-power (total).	Total cost per hour (estimated).	Cost per 1,000 c.p. per hour (estimated).
		(approx.)		(approx.)
1882	Gas (Flat Flame) 222 lamps	2,720	3/-	1/-
1882	Jablochkoff Electric Arc Lamps 50	13,250	6/-	5½d.
1914	Flame Arcs .. .. 66 (Gilbert and Beck); Tungsten Lamps .. 140; Incandescent Gas .. 20	192,000	10/-	0¾d.

[11] Recent Progress in Gas Lighting. *Illum. Eng.* (Lond.), Vol. III., 1914.

[12] Report on Experiments with the Electric Light on the Victoria Embankment, by Sir J. W. Bazalgette, C.B., Engineer, and T. W. Keates, Consulting Chemist, 1879.

Report on Victoria Embankment and Waterloo Bridge Lighting, by Sir J. W. Bazalgette, C.B., 1882.

It is interesting to notice that the *maximum* illumination in the cases cited did not exceed about one-quarter of a foot-candle, while the minimum was often about *one-fiftieth* of a foot-candle—perhaps *one-tenth* of what one would expect in a well-lighted street to-day.

From this report it would appear that the usual form of lighting in the City of London area at that date consisted of gas lamps consuming about 5 cub. ft. of gas per hour, and giving about 14 candle-power, and spaced about 66 feet apart.

In 1883 the earliest experiments with electric incandescent lamps for street-lighting were undertaken in Holborn Viaduct, 32 and 16-candle-power lamps being placed on posts 12 feet high and 66 feet apart. Sir William also describes some experiments with electric incandescent lamps in Wimbledon, then still lighted by oil lamps. This is interesting as showing that in remote parts of London oil lamps were still in use for public lighting, even as late as 1883.

article in the *Electrician*[13] states that in 1910 1,897 feet of roadway in Cheapside were illuminated by 2,800 candle-power Oliver flame arc lamps. Besides being more powerful these lamps are better placed and nearer together than in the old days. A rough calculation shows that the total light provided is *now quite eight times* what it was in 1882; yet, as near as one can estimate, the cost is probably about the same.

Within recent years substantial increases have been made in the light provided in many London streets. Thus, in High Holborn the present lamps give approximately ten times the light that prevailed in 1900, and in Fleet Street the total candle-power provided was, roughly, 3,600 in 1905, 24,000 in 1908 (high-pressure gas bracket lights), and 28,000 in 1913 (high-pressure gas lights, centrally suspended)—an enormous increase for such a short period (eight years only). These are typical examples, and serve to show the progress of recent years.

FIG. 3.—Night view of Cheapside, illuminated by Oliver flame arc-lamps.

In Cheapside, at the date of this report, Brush arc-lamps giving about 400 c.p., and placed 150 ft. apart. An

In most cases, owing to the great improvement in the efficiency of artificial

[13] Dec. 16th and 23rd, 1910.

illuminants, these large increases in candle-power have been made without great expenditure. I have already pointed out the nature of progress in gas-lighting. These advances were accompanied step by step by corresponding improvements in electric lighting, each new development calling out some new effort on the part of the rival illuminant. Thus the progress of electric lighting between 1880 and 1890 was probably indirectly responsible for the coming of the incandescent mantle, about 1895. Similarly, the development of the inverted mantle, about 1905, and of high-pressure gas lighting a little later, were met by the invention of the metallic filament lamps and the flame arc lamp. Whereas with the old carbon filaments one could not, in the best circumstances, obtain more than about 0·3 c.p. per watt, with the ordinary metallic filament lamp one can get about 0·75, or even, in the higher candle-powers, 1 c.p. per watt. Similarly, the old enclosed arc lamps yielded only 0·5 c.p., the best ordinary open arc lamps of later years 1 c.p. per watt, but the flame arc lamps developed during the last five years as much as 5 c.p. per watt. At the present moment engineers are all interested in the coming of a new form of metallic filament lamp, which is stated to yield as much as 2 c.p. per watt, and it is probable that lamps of this kind, yielding 2,000—3 000 candle-power, may soon be in common use.

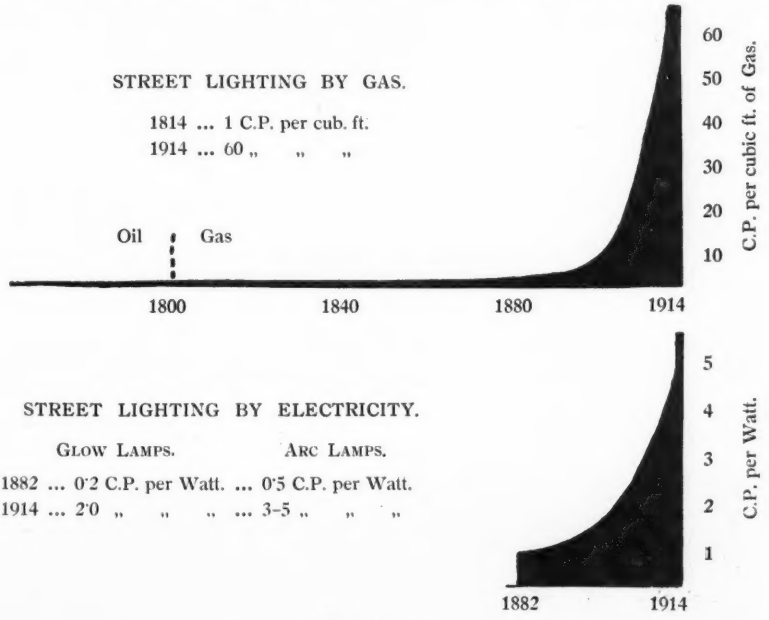

Fig. 4.

While the flame arcs, like the high pressure gas, have been used chiefly for the lighting of main streets, the metallic filament lamps have been widely used for side-street lighting, but Holborn provides an instance of the use of clusters of several metal filament lamps for main street lighting.

In view of this constant improvement in illuminants, it is obvious that the nature of the contract entered into by a municipality for street lighting is an important matter. Not infrequently the existing contract has tied the public to a certain expenditure of energy irrespective of the improvements in illuminants that may occur meanwhile, and it was only when the contract expires that advantage of such improvements could be taken. On the other hand, in some cases, as in the

FIG. 5.—Night view of Queen Victoria Street, lighted by "Staggered" Keith high-pressure gas lights (one of the streets most recently converted in the City of London area).

FIG. 6.—Oxford Street lighted by Excello flame arc lamps, mounted two on a post and arranged down the centre of the road.

City of London, a special clause has been inserted providing for the possibility of changes being made to the mutual advantage of the company and the public. On these points more will be said later. For the moment we may point to the City of London, which undertook great improvements towards the end of 1911, as an instance of what may be done by taking prompt advantage of modern illuminants. It is estimated that as a result of these improvements the total candle-power in the City area for both gas and electric light, will be increased by no less than 600,000 candle-power; nevertheless there will be an annual saving in expenditure of over £6,000 per annum.

IMPROVED METHODS OF STREET LIGHTING.

At the present time one of the most important factors in street lighting is the increased speeding up of traffic and the all-pervading motor-vehicle. In order to enable drivers to steer their way in London traffic they must be able to see a long way ahead, and an adequate illumination is desirable. On the other hand, people are beginning to ask whether this enormous increase in light is not sometimes misapplied. It is a somewhat curious fact that in the old days of oil-lighting, when the amount of illumination was becoming so obviously deficient in the busier streets, authorities like the great chemist Lavoisier busied themselves in the design of new lanterns which would use the available light in the best possible way. The tendency at that time was in the direction of screening the actual lights from the eyes of drivers and pedestrians and directing most of the light on the roadway.

With the coming of more abundant supplies of light, people seem to have become more careless how it is used. Most thoughtful observers agree that the present street lights err on the side of "glare." They illuminate the pavement brightly, but they also throw their rays into the eyes of passers by, producing an inconveniently dazzling effect. Seeing how rapidly a driver of a motor-vehicle must steer, it would not be surprising if the sudden exposure to these bright lights were sometimes the cause of an accident, and, as a matter of fact, collisions have occurred which were ascribed to this cause. No doubt before long enlightened public opinion will insist on better methods of screening public lamps, and on their use high up at a reasonable distance from the eye. Sometimes the glaring effect is intensified by the fact that new and more powerful illuminants are planted on lamp-posts intended in the past for lamps of far lower brilliancy.

FIG. 7. — Ornamental standard in Trafalgar Square, once equipped with flat-flame burners giving about 120 c.p., now carrying high-pressure gas lamps giving several thousand candle-power. It is suggested that these lamps, being at such a low level, should preferably be screened to some extent from the eyes of passers-by.

As an instance may be mentioned the massive three-light post on the island in Trafalgar Square. In the past the light in each of these globes came from a cluster of Sugg flame-burners giving perhaps 120 candle-power; to-day, 2,000 candle-power high-pressure gas lamps have been substituted in each lantern, and this powerful light is concentrated within a much smaller area than was the case with the old flat-flame burners. These lamps, it may be suggested, would answer their purpose better if the direct

rays were screened from the eyes of passers-by. Similar considerations apply to the use of powerful high-pressure gas lights and flame arc lamps outside shops. In the City area there is a regulation requiring these lamps to be screened on the side facing the street, and to my mind it would be no hardship if this regulation were extended to the rest of London. Even in the City of London this requirement, although applied strictly to lamps put up during the last few years, is not retrospective; so that one still sees glaring lamps which were put up before the date of this regulation.

Another point that has been investigated in some Continental cities is the effect on the driver of a motor-vehicle of suddenly emerging from a comparatively dark side-street into the full light of a brightly illuminated main thoroughfare. This is believed to have a distinctly dazzling effect. Accordingly in some cases the method has been adopted of using lamps of progressively increasing candle-power as one passes from the more remote portions of the side-street to its brightly lighted termination. In this way one avoids the shock of passing at once from dimly lighted surroundings into great brightness, and the eye is gradually accommodated to the change.

There are many other problems in connection with the arrangement of street lamps. Much has been made of the enormous increase in candle-power of recent years, but, as pointed out above, it is most important that this light should be properly distributed—a fact which was thoroughly recognised by Sir William Preece in his already quoted report. There has been some difference of opinion as to how this distribution should be accomplished, but it seems now to be pretty generally agreed that, while some light should be allowed to illuminate the houses of a street and surroundings, so that they are not in complete shadow, *most* of the light should be directed downwards on the pavement and roadway. There is room for enterprise in the design of reflectors more perfectly designed to accomplish this. Similarly most people would agree that the illumination along a street should be fairly uniform and not "patchy"; *i.e.*, that the parts of the pavement most remote from the lamps should not be left in complete darkness while the portions near them be extravagantly lighted. To accomplish this, special prismatic globes have been designed for use with flame arc lamps (such as the Excello "dioptric" and the prismatic device used with the Oliver lamps in Cheapside) which deflect the rays of light in such a way as to increase the intensity on these more remote portions of the road. At present the difficulty is to accomplish this spreading of the light without increasing the effect of glare to persons approaching the lamps from a distance.

The question of providing uniform illumination is closely associated with the problem whether to use very powerful lamps high up or lamps of moderate candle-power at more frequent intervals. The latter method, though more usual in side streets than main streets, is thought by some to make it easier to provide uniform illumination. Lighting of this kind approaches more closely to the distributed oil-lighting by private householders of past centuries.

The method of arranging the lamps in the street differs according to the locality. Oxford Street is lighted by two sets of flame arc lamps mounted on tall central posts. Fleet Street was for a short time lighted by high pressure gas lamps attached to the houses by brackets, and some such lights are still in use. Most streets, however, are lighted by lamps on posts "staggered" on either side of the roadway.

The growing interest in street lighting problems led the City Corporation of London in 1909 to appoint a deputation composed of members of the Street Lighting Committee to visit a number of Continental cities,[14] many of which I myself visited afterwards in the same year. They came back impressed with the advantages of the method of "central suspension" (lamps slung on wires spanning the roadway), and reported:—

(1) That wherever possible streets should be lighted by means of centrally hung lamps with lowering gear.

[14] A Report issued by the Deputation appointed by the Streets Committee of the Corporation of London to study the lighting of Continental cities. Abstracted in the *Illum. Eng.*, Vol. II. 1909, pp. 526, 623, 677.

FIG. 8.—A view of Fleet Street formerly lighted by Keith high-pressure gas lamps on brackets.

FIG. 9.—Fleet Street as it is now (1914) lighted by centrally suspended Keith high-pressure gas lights.

"This we think particularly important in the City of London, where the number of obstructions upon the footways in the form of lamp-posts, bins, letter boxes, &c., is so large."

(2) That open spaces should be lighted by means of lamps upon standards, fitted with lowering gear.

(3) That high pressure gas lamps with inverted burners should be adopted as an illuminant, but where gas is impracticable, electricity with open arc and flame arc lamps should be installed.

The chief novelty at that time was the application of this central suspension method to gas lamps. This method was tolerably familiar in connection with electric lamps, but many people questioned its practicability in connection with high pressure gas. I had, however, witnessed its use in Stuttgart, and as a matter of fact it is now widely used. The use of this method naturally assumes that rights can be obtained to fix the cables to the houses on either side of the street, a privilege that is enjoyed by the City of London, but limits the applicability of the system elsewhere. Curiously enough this method was recommended by Sir Wm. Preece in his report of 1883, but he foresaw this difficulty; another drawback at that time was that, owing to the comparatively low candle-power available the lamps would have had to be suspended at a somewhat lower level; this might meet with objection from the Fire Brigade owing to the passage of the escapes being impeded.

In view of the keen interest taken in this method of lighting it is of interest to mention that Mr. Chas. Baker, when acting under Mr. J. W. Lieb, employed it with electric lamps in Milan as far back as 1887. Through the courtesy of Mr. Hopwood, of the Patent Office Library, several old prints are here reproduced showing that its use in the streets of Paris in connection with oil-lamps goes right back to the eighteenth century; the level at which these lamps were suspended was necessarily low, a fact illustrated by the cartoon showing the rope disarranging the lady of fashion's head-dress. One of the prints shows the lamps being withdrawn to the side and lowered in a manner quite similar to the street lamps of to-day.

FIG. 10.—Central Suspension of high-pressure gas lamp in the City of London area.

FIG. 10A.—Central Suspension of electric lamps in the City of London area.

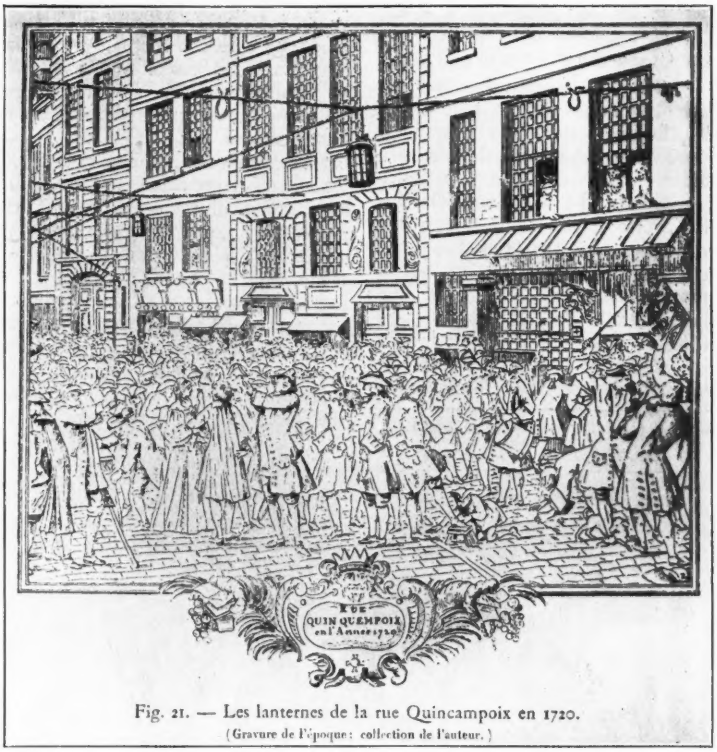

Fig. 21. — Les lanternes de la rue Quincampoix en 1720.
(Gravure de l'époque : collection de l'auteur.)

FIG. 11.—Citizens admiring the lanterns installed in the rue Quincampoix (Paris) in 1720. —*Defrance, p. 52.*

This visit of the City Corporation delegates had been mentioned as an illustration of the growing recognition of the importance of public lighting in this city. Gentlemen representing American cities frequently come over to inspect the latest European improvements. In one case the city dispatched not only the engineers responsible for the gas and electric lighting, but also their financial adviser on street lighting. It is interesting to compare the public lighting of London with that in Continental and American cities. As is well known, Berlin was one of the pioneering cities in the use of high pressure gas and it is only recently, through the energetic action of the Gas Light and Coke Co., that its extension here has been comparable with that city. The United States has certainly been backward in the development of use of high pressure gas, but there will doubtless be great progress in this direction shortly. Visitors from the States have expressed the keenest interest in the installations here.

There is, however, one point by which American and Continental visitors never fail to be struck—the great diversity of lighting in London. To them the idea of so many separate authorities being in such close proximity all following their own devices comes as a revelation. Abroad it is the almost invariable rule for cities to be lighted on a consistent general plan. However, owing to recent improvements the lighting in our main streets need not fear comparison with

that of other cities, although a few years ago this would not have been the case.

Various Classes of Streets, Public Squares, Parks, &c.

A distinction ought clearly to be drawn between the methods of lighting in a side street, a busy commercial thoroughfare, and in a wide street lined with buildings of architectural distinction. On this point the work of the Joint Committee engaged in preparing the Draft Standard Specification for Street Lighting has a most important bearing. I should like to mention that the nature of this Specification was exhaustively dealt with in a recent paper by Mr. A. P. Trotter[15] before the Illuminating Engineering Society, which gave rise to an interesting discussion at two joint meetings with the Institutions of Gas and Electrical Engineers and the Institute of Municipal and County Engineers. Moreover, as was pointed out in the recent International Roads Congress, there are certain highways running out of London which constitute arteries of traffic and deserve special illumination. It has been suggested that the lighting of such "arteries of traffic" should be the care of the State, and that it should not be left to the particular parishes through which they happen to run. Such roads are now used for speedy traffic, no longer for slow-moving local vehicles. Surely, therefore, some portion of the revenue derived from the taxation of motor-cars might be

[15] *Illum. Eng.* (Lond.), May and June, 1913.

Fig. 12.—Showing how the old oil-lanterns were suspended on ropes and lowered at the side for cleaning, &c.—*Allemagne, p. 457.*

applied to the *lighting* as well as the general upkeep of such roads.

Open spaces and squares of architectural and historic interest also deserve special artistic treatment. Continental

FIG. 13.—Early caricature showing a lady's head-dress impeded by overhead lantern (executed in London by order of King Louis XVI.).—*Allemagne, p. 469.*

visitors not infrequently regard the lighting of Trafalgar Square as too heterogeneous, quite a number of entirely different types of lamps and standards being represented. This compares unfavourably with the uniform scheme in the Mall. The method used in some Continental squares of mounting groups of powerful lamps on very high columns which are works of art by day as well as by night is preferred.

It has recently been pointed out that the lighting of the space adjacent to the Houses of Parliament and Westminster Abbey is not sufficiently bright in comparison with the brilliant illumination in Whitehall leading up to it; yet if the candle-power of the low level lamps in this neighbourhood were much increased, the use of some form of diffusing glass in the lanterns would seem desirable in order to avoid glare.

Another point of interest is the artificial illumination, by concealed lights, of national memorials so that they are visible by night as well as by day; in fact, during the night time they might be made to stand out more vividly than in the day-time; to be really "memorials by night" as well as by day. Such methods are very effectively used in some Continental parks.

It may also be suggested that fuller use would be made of our parks in the evenings if they were lighted more completely. Parks are spoken of as the "lungs" of London. Why not, therefore, encourage people, by providing attractive lighting and music in the evenings, to use them more fully during the night time? In some of the American parks very effective use is made of avenues of lamps in white glass globes,

FIG. 14.—Decorative iron gateway and pillars in St. James's Park. It is suggested that the effect of the lantern on the left, at night, would be improved if it were fitted with panes of white diffusing glass, so as to screen the lights and show off the lantern to better advantage.

producing a mild and more decorative effect than the clear glass lanterns so usual in this city.

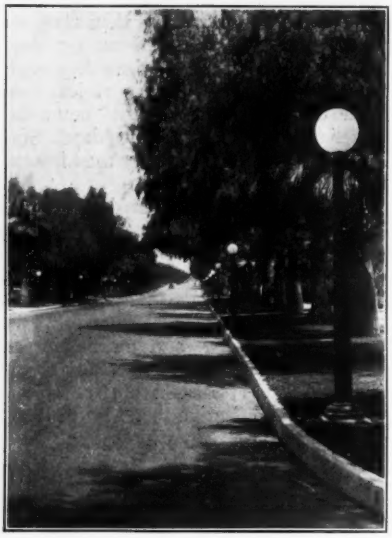

FIG. 15.—Ornamental lamp-posts with white glass (Alba) globes, as used in some American parks.

LAMP-POSTS, LANTERNS, AND DECORATIVE LIGHTING.

A few of these lamp-posts with clusters of white glass globes have been recently installed in London. Some of the standards of this type are of specially graceful design. Reference may be made to a recent paper by Mr. C. F. Lacombe[16] on this subject, in which he states that the designs of posts used in New York are all submitted to an Art Commission before adoption. Seeing that lamp-posts are such prominent objects by day as well as by night this is only reasonable, and the matter is one that should be considered by all who have an influence on the beautifying of this city. Sir Aston Webb, in a recent speech before this Society, advocated a Ministry of Fine Arts; let us hope that when it comes, it will exercise some effective supervision over the artistic aspects of illumination.

Besides the design of the standards supporting public lamps there is still very much to be done in connection with lanterns. There is a practically unexplored field in the artistic aspects of the lighting of streets, and the illumination of the outsides of public buildings.

Similar considerations apply to illuminated signs. One may agree that the indiscriminate use of flashing advertisement signs should be deprecated. Light injudicially used may become a nuisance just as much as a violent noise. But one should also consider the artistic and really useful possibilities of illuminated signs. Why, for example, should not all the chief public buildings, railway stations, and post offices be clearly indicated to strangers in this way? And why should it not be possible to illuminate the names of our streets by night?

LIGHTING OF BRIDGES, TUNNELS, AND SUBWAYS.

Artistic considerations also play an important part in the lighting of bridges. As a rule the lighting is done exclusively from lamps on the parapets. In London, many bridges—such as Blackfriars and Waterloo—are lighted by gas, but Westminster Bridge, Hammersmith Bridge, and others are lighted by electricity. In the case of Westminster Bridge, of which a photograph is shown, the old lanterns have an imposing effect, in keeping with the proximity to the Houses of Parliament. Each standard carries three lanterns. In all, thirty-six 200-watt and thirty-six 100-watt metal filament lamps, backed by enamelled reflectors and green glass, are used.

It might be supposed that the effect of bridge-lights seen from a distance would be valuable from a decorative standpoint, in the same way as the parapet lights on the Embankment of London are regarded as being purely architectural features and not in order to light the roadway. Indeed, in such cases the appearance of the standards by day is possibly even more important than by night.

[16] "Street Lighting of Greater New York," C. F. Lacombe. Trans. American Illum. Eng. Soc., May, 1913.

FIG. 17.—Lighting of Mall, Central Park, New York, by tungsten lamps in white glass globes. This illustrates the decorative effect of a long series of lamps in diffusing globes, lining a long main avenue.

It appears, however, that the watermen dislike bright lights being visible on the bridge, and consequently on Westminster Bridge they have been shaded in the manner described. It is asserted that the reflection of lights in the water is apt to be confusing on misty nights as they are liable to be mistaken for navigation lights.

It has been remarked that a judicious arrangement of the lights on a bridge add greatly to its decorative appearance by night. On one of the bridges in Berlin the lights are carried by the statues lining each side of the roadway, which seems a very effective way of treating the problem.

Besides the lighting of bridges the illumination of subways, tunnels, &c., plays an important part in London traffic. During recent years a number of new subways have been opened for foot traffic. A defect in the lighting of some of those under the roadway in the neighbourhood of railway stations is that the sources are not completely screened and have a distinctly dazzling effect. In this respect the methods employed in the Underground Railways, where the lights are sunk in slots in the ceiling, might well be imitated.

Experience shows that, provided the lamps are well-shaded, a very moderate illumination suffices for such subways. The prejudicial effect of a glaring light often more than counterbalances any increase in light that the brightness of the illuminant may secure.

Of special interest is the lighting of the tunnels underneath the Thames. The Blackwall and Rotherhithe tunnels, which

are approximately 1¼ miles long, are both lighted in substantially the same way. The Woolwich and Greenwich footpath subways are also illuminated in a very similar manner. In the Rotherhithe tunnel there are in all 800 incandescent lamps, 35-watt in the tunnel and 50-watt on the stairs, arranged in three rows on the ceiling, the lamps in each being 30 feet apart. These lights are protected by strong clear glass outer coverings. A measurement in 1911

FIG. 21.—Night view of standard carrying incandescent electric lamps, on Westminster Bridge. In the distance the lights of the Embankment.

showed that the average illumination in the tunnel was 0·366 ft.-c.—a value close to that recognised as suitable for general lighting of goods yards, railway platforms, &c. Owing to the use of the white tiled surroundings the tunnel appears brightly lit.

In view of the narrow space and the turnings in the tunnel it is of course highly essential that precautions should be taken against any failure in the light. Through the kindness of Mr. Baker an opportunity was provided of visiting this tunnel and to notice the special change-over switch, by which the lighting is automatically changed over from the London Electric Supply to the Bermondsey Supply in less than 20 seconds.

This switch is the more interesting in view of the fact that while the London Electric Supply is an alternating one the Bermondsey Supply is direct current. Consequently, in order to use the same instruments, it is necessary to arrange for the switch to start up motor-generators transforming from direct to alternating current, and all this is carried out in less than half a minute.

On the Woolwich footway subway two 16 c.p. lamps in stout glass fittings are arranged on the ceiling in a single row at distances 18 ft. 3 ins. apart. Here also there are two alternative systems of switching available, but as the tunnel is given up to foot-traffic only it was not considered necessary to have a special change-over switch.

At the sub-station, however, a switch is provided by means of which the change over can be accomplished by hand.

THE CONTROL OF LONDON'S LIGHTING.

In conclusion, it may help to explain some of the anomalies in public lighting if something is said as to the historical development of London, which is in many respects unique. London has been described as "many cities within a city." There is the original City of London, which enjoys certain special privileges. Adjacent to it are such districts as Westminster, which have an ancient history behind them. Outside these areas there is the fringe of more modern districts which have gradually coalesced, and these in turn are surrounded by the suburbs.

The effect of this development on lighting conditions is unquestionably profound, although I have not yet been able to trace out the past history of illumination with any completeness. There are many obscure points. We have seen, however, that the lighting of London was originally carried on by individual householders. After several fruitless attempts at private contracting it seems to have passed into the hands of the Commissioners of Sewers in the City of London, and the Vestries in neighbouring

FIG. 19.—Ornamental (B.T.H.) street lighting standards carrying tungsten lamps in diffusing glass globes, recently installed in the Earl's Court Road (London).

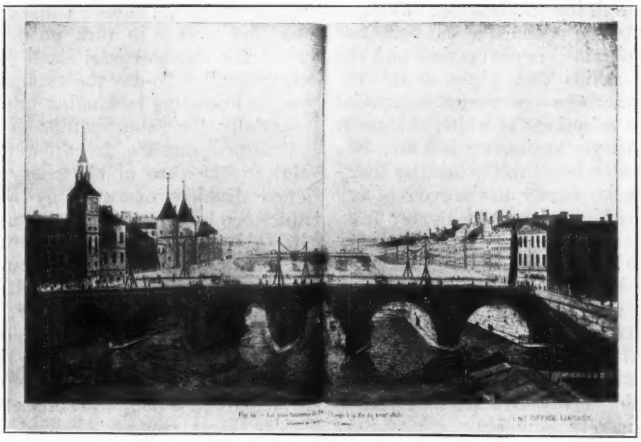

FIG. 20.—Three suspended lanterns on Pont du Change, Paris, at the end of the XVIIIth Century.—*Defrance, pp. 64–65.*

parishes. I understand that prior to the formation of the Borough Councils in London there were often quite a number of Vestries within the area of what now constitutes a borough, each of which negotiated its own contracts and supervised its own lighting. The present arrangement, under which each borough council superintends its lighting through a lighting committee, is thus a distinct step towards centralisation; some might consider that in the case of lighting this tendency should be carried further still.

At the present moment there are in the County of London, exclusive of the Cities of London and Westminster (which in rateable value far exceed any other borough), twenty-seven such boroughs. These, however, are by no means the only authorities concerned with lighting. The London County Council, which was formed in 1888, took over the duties previously discharged by the Metropolitan Board of Works. It still retains control over the lighting of a section of the Embankment (for which it generated its own current until 1909), and over the subways, tunnels and bridges outside the City of London area. In addition it undertakes the planning of new roads and arranges incidentally for their lighting; but after completion such roads are handed over to the control of the local authority in whose district they occur, and the lighting maintained by this authority. The Council's consent has also to be obtained in connection with the laying of mains and pipes under the streets, and there are numerous special regulations affecting the width of streets, obstructions, precautions against fire, &c., which more or less directly bear on lighting problems. Lastly, in the event of any borough wishing to borrow money (*e.g.*, for extensions in lighting, electricity supply, &c.), the Council's consent must be obtained, and the money is frequently borrowed through them; but should this permission not be accorded they may appeal to the Local Government Board.

I understand that in London the Police do not take any active part in street-lighting, merely reporting any failure on the part of a lamp. But it appears that in Ireland the Police sometimes exercise much more control.

It will be seen, therefore, that within the area of the County of London (approx. 117 square miles) there are at least thirty authorities concerned in the control of lighting. In this respect it presents a complete contrast to most cities abroad. But the position is complicated by another thing—the number of distinct gas and electrical supply companies by which it is served. In London there are half a dozen gas companies, the great majority of the lighting being done by two (the Gas Light and Coke, and the South Metropolitan), fifteen municipally owned electrical enterprises and fourteen private electrical companies; and the powers enjoyed by the gas and electrical concerns as regards lighting are substantially different.

The facts mentioned above are in themselves sufficient to account for many anomalies. But this is not all. When we look back and recall the ruinous competition between the large numbers of gas companies previous to their amalgamation—a process which was substantially complete by 1882 but may still go further—it seems surprising that the lesson was not taken to heart in connection with electrical supply, which began about that date. It is said that in the early days of gas lighting mains from several distinct companies were sometimes led into the same house, and the expert fitter, if in doubt to which source he should connect, applied his nose to each in turn until he recognised the characteristic smell of his own company.[17] To-day the various gas companies operating in London produce substantially the same quality of gas (and of course operate in different areas). But in the case of electricity we have some districts operated by alternating and some by direct current, some between 100—110 volts and some between 220—240 volts. Naturally there has been for some years a desire for standardisation. At the present moment there is a Bill before Parliament for the consolidation of London's electrical supply. Whatever be its fate, it would seem that co-operation in some form is bound to come eventually.

The local control of lighting by so many different authorities is a source of

[17] Lecture by Mr. W. J. Liberty (*loc. cit.*).

inefficiency. The nature of the contracts entered into are widely different. In some cases the borough enters into a contract which offers no inducement to the contractor to install improved illuminants as they appear; in others (the City of London is an enlightened example) a provision is made for the contracting parties to share any resulting benefit. In the South of London the contracts with the gas company practically always involve the purchase of the lamp-posts and their maintenance by the company, but one borough, Bermondsey, prefers to attend to its own maintenance. In the City of London, on the other hand, the recent contract specifies that the standards, suspension gear, &c., provided by the Gas Light and Coke Co. become the property of the City at the end of ten years; while the corresponding electrical appliances may be purchased at the end of ten years for £2,000. I am told that the lighting committees in some boroughs show quite an interest in the technicalities of lighting; in others the details are left to the borough engineer, and the committee practically only interests itself in the question of finance. (There is also one borough in which the engineer does not deal with lighting, which is left to the town clerk.)

There are many other points that might be mentioned. But enough has been said to show what a complicated problem the lighting of London really is, and to show that there is a reason for many anomalies which at first sight would appear absurd. But a good case can be made out for the view that the lighting of London should be considered as a whole *by one central authority* if this could be brought about. The lighting of streets is a most complex technical problem, and in the interests of traffic a most important one. The suggestion has recently been made that a Traffic Board should be appointed to deal with traffic problems throughout the London area, the view being rightly taken that traffic is a matter which interests the county as a whole and not any particular borough. Now the lighting of London should be treated on the same lines. In these days of rapid locomotion the streets are not used only, or even mainly, by people residing in a certain neighbourhood. The method of lighting adopted should therefore be determined by expert knowledge of the requirements of the particular class of street to be illuminated, and not by purely local financial, political, or other considerations. It would be far better if, instead of illumination being left to local authorities and their engineers, who can only devote a small proportion of their time to lighting matters, it were made the care of some adequately equipped central authority *ad hoc*, who would keep themselves fully conversant with the progress of other cities, who could take a broad and impartial view of each problem as it arose, and who would be prepared to carry out experiments and collect full statistical data and information on the subject.

I understand that a few years ago the late Sir Geo. Livesey endeavoured in vain to bring about a common system of lighting and contract in all the South London boroughs under the supervision of his company. But even should it be found impracticable for the lighting of London to be actually paid for and maintained from a single source, it might still be possible to create a central authority on street lighting which could generally supervise and issue recommendations on the subject and grant aid to those boroughs which have important thoroughfares in their district but cannot afford to illuminate them in a first-class manner.

As an example of the feeling in favour of some common agreement on this subject may be mentioned the Draft Standard Specification prepared by a Joint Committee composed of members of the Illuminating Engineering Society, the Institutions of Gas and Electrical Engineers, and the Institution of Municipal and County Engineers last year.[18] The formation of this Committee would hardly have been possible a few years ago, and shows that gas and electrical representatives are willing to co-operate for a common good. There have also been instances of joint contracts, notably in Holborn and in the City of London, in which an amicable understanding was entered into that certain streets should be lighted by gas and others by electricity. One function of such a central authority

[18] *loc. cit.*

would be to allocate certain sections of London to the respective illuminants and to do away with a great deal of needless bitterness, resulting from the present arrangements.

And lastly reference should be made to the good work of the Road Board with which our Chairman is associated, and which will doubtless be to the front in connection with experiments on street lighting, particularly those "arteries of traffic" of such importance to fast-moving vehicles. On the Lighting Board suggested bodies as the Road and Traffic Boards and the London County Council would naturally be represented.

In conclusion I wish to acknowledge the very considerable help which I have received from many quarters in connection with the preparation of this paper, and in particular from the following:—

Mr. A. P. Trotter, Mr. Frank Bailey, of the City of London Elec. Supply Co.; Mr. Chas. Baker, Electrical Engineer to the London County Council; Mr. F. W. Goodenough, of the Gas Light and Coke Co.; also Messrs. Stokes and Talbot, of the South Met. Gas. Co.; Mr. W. J. Liberty, Inspector of Public Lighting to the City of London; The British Thomson-Houston Co., Union Electric Co., Messrs. Jas. Keith and Blackman, and Messrs. Sugg & Co., and to Dr. Louis Bell, Mr. C. F. Lacombe, and the MacBeth Evans Co., in the United States, for putting at my disposal some most interesting data on Continental and American cities.

I also wish to acknowledge the help of my assistant Mr. J. S. Dow and express my appreciation of the skill of Mr. V. H. Mackinney, by whom a number of photographs used to illustrate this paper were taken.

CORRESPONDENCE.

THE RATING OF MODERN ILLUMINANTS.

We have received a copy of a letter from Mr. Justus Eck which has been widely published in the technical press, dealing with the question of the best method of rating the candle-power of modern illuminants. The question is an important one, especially in view of novelties such as the half-watt lamp, and the considerable number of illuminants that are now available for the same field of action.

Until recently, he points out, metal filament lamps were mainly rated in terms of the horizontal c.p. while for arc lamps mean hemispherical c.p. has been chiefly used. The present moment seems a fitting one to establish the latter method as the standard practice, although the polar curve showing the distribution of light should also be given.

Mr. Eck refers to the practice of rating lamps in terms of their maximum candle-power in some special direction; for example, a well-known flame arc lamp was found to give about 6,000 c.p. at about 20 degrees below the horizontal plane with a consumption of 600 watts. Is it justifiable to call this a one-tenth watt lamp, or ought one to describe it in terms of the mean hemispherical c.p. as "a one-seventh or one-sixth watt lamp."

Another point to be considered is whether any account should be taken in rating lamps of the diminution of candle-power of an illuminant during life.

[We agree with Mr. Eck that the system of giving only the c.p. in the maximum direction is an unsatisfactory one and that the measurement of mean hemispherical c.p. surely offers a better basis of comparison. The question is one on which there ought to be general agreement and which should come before the notice of the Illuminating Engineering Society in the near future.—ED.]

TRANSACTIONS

OF

The Illuminated Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE ANNUAL DINNER.

(Held at the Trocadero Restaurant, Piccadilly, London, W., on Friday, February 13th, 1914.)

THE Annual Dinner of the Illuminating Engineering Society took place as announced above on Feb. 13th, the President Elect, Sir William Bennett, K.C.V.O., F.R.C.S., being in the chair.

There was a good attendance of members, and it was generally agreed that the dinner was one of the most enjoyable that the Society has held.

Toast: "The Illuminating Engineering Society."

After the usual Loyal Toasts had been given,

SIR BOVERTON REDWOOD, BART., F.R.S.E., proposed "The Illuminating Engineering Society." He referred to the origin of the Society in 1909, when he was present at the inaugural meeting, and to the admirable manner in which Professor Silvanus P. Thompson had presided over the destinies of the Society for four and a half years. For this the Society owed him a deep debt of gratitude. Professor Thompson's work as President of the Society, he said, had largely contributed to the removal of any initial obstacles that had existed and had laid the foundation of the present position of the Society and of the cordial appreciation in which it is now held all over the world. The good work which the Society was doing was also due in a large measure to the sagacity of the Honorary Secretary, Mr. Leon Gaster, and he would like to make special reference to the admirable standard maintained by him in the official journal (*The Illuminating Engineer*), at a considerable personal sacrifice.

During the five years which had elapsed since its formation, the Society had secured the co-operation of the teaching and medical professions, as well as the Library Association and other bodies. It had also been instrumental in forming joint committees with other institutions to deal with various problems in lighting. It had been instrumental in the publication of the little booklet entitled *Light and Illumination; Their use and Mis-use*, which explained in popular terms the distinction between good and bad lighting. All this tended to educate the public.

Possibly, however, the most important feature of the Society's work had been the promotion of international co-operation. Thus we had seen the formation of an International Commission on Illumination, and of national committees to deal with the subject in various countries. There were now Illuminating Engineering Societies in Great Britain, Germany and the United States. The Illuminating Engineering Society had also taken its part in many Continental Congresses, notably in Brussels, Turin, Milan and Paris, dealing with industrial and

hygienic aspects of lighting. Clearly the keynote of the Society's programme was "co-operation," and this was emphasised by the fact that it had been able to obtain the co-operation of the medical profession in securing the services of its new President, Sir William Bennett, whose name it gave him the greatest pleasure to associate with the toast.

Sir William had had a long and distinguished career, and was probably well known to most for the very valuable services which he rendered in connection with the South African War. As a member of the consulting staff of several hospitals he had had unique opportunities of appreciating the importance of light and its effect on the human body, and his appointment as surgeon to His Majesty the King was evidence of the great appreciation with which he was held in the medical profession. Sir William had also taken keen interest in many other scientific questions, and he was an authority on the subject of smoke abatement. It was with the greatest confidence that he gave the toast of "The Illuminating Engineering Society," coupled with the name of the President-elect, Sir William Bennett.

SIR WILLIAM BENNETT, K.C.V.O., F.R.C.S. (President-Elect of the Illuminating Engineering Society), in replying to the Toast, first expressed his appreciation of the kind terms in which it had been proposed, and the cordial manner in which it had been received.

When he had first been asked to take up the Presidency of the Society he felt that he must decline on account of his lack of familiarity with the subject. But in a subsequent visit the Hon. Secretary had pointed out that the interests of the Society were by no means confined to technical matters, and that it had aims and ambitions closely affecting the health of the community. Mr. Gaster also pointed out that in these circumstances the Society hoped—in fact, was almost entitled to ask—for the aid of the medical profession in forwarding its views. He therefore felt that he had no alternative but to reconsider his decision, and that accounted for his presence in the Chair.

He had been speaking to a friend of his quite recently who, after an absence of more than 50 years, had returned to this country about fifteen years ago. He said that the thing which struck him most on his return was the improvement in lighting, which he thought was a matter of the first importance; and when one came to think of it, he did not think his friend was wrong. Generally, the ordinary man in the street was apt to view the matter of artificial light from the point of view that the excellence of it lay in its intensity; in other words, the more he got the better it was. In doing so, however, he lost sight of the fact that too much light might sometimes do as much harm to health, and sometimes a great deal more harm to health, than too little light, and it was an easy thing to be obsessed in matters of this description.

The important point about light, and one which was sometimes of more consequence than its intensity, was the proper arrangement of it in relation to the purpose for which it was to be used, because people working under disadvantageous conditions of lighting, of necessity could hardly keep in proper health, and imperfect health was incompatible with efficiency. The output of workers under these conditions must be defective.

A very good object-lesson was provided in the lighting of schools. Too little light in a school led to eye-strain and brain fag. Too much light, on the other hand, produced eye irritation, brain irritation, headaches, neurasthenia, and other evils. But the matter was not limited to the amount of light. Improper arrangement and imperfect disposition of the illuminant often led children to use one eye more than the other owing to the lighting being received mainly on one side, whilst the disadvantageous placing of the light sources may at times lead to spinal curvature and other troubles owing to the cramped and unnatural posture adopted by children in their efforts to obtain the best of the light. It was a common thing to say that children were suffering from brain fag and brain fatigue through overwork, whereas in a very large number of cases the brain fatigue was not due to overwork but to defective lighting.

It was notorious that the use of spectacles was increasing in children, and there was an elaborate system by which these were provided under medical supervision;

yet there was no methodical inspection or rational guide to the proper lighting of the rooms in which these children worked, and it would be extremely interesting to find out what the effect would be upon the number of spectacles supplied if in any given school there was instituted a proper supervision of the lighting arrangements.

These remarks also applied to lighting in factories and other industrial concerns, and it was satisfactory to know that the Departmental Committee appointed by the Home Office was carefully considering this matter. At the same time he hoped the Society would not relax its efforts in consequence of the appointment of this Committee; indeed, he hoped it would proceed still more energetically than before.

There was also the very interesting question to be investigated of when the artificial light should be substituted for daylight. It was a difficult problem. He did not know whether it might be possible to arrange some sort of automatic photometer or something of that kind to indicate when artificial light should be used. If such an instrument could be usefully employed he was sure that some member of the Society would be able to design it.

In conclusion, he referred to the help which the medical profession could give in the serious work which the Society was doing in what might be called the less technical aspects of illumination. Not only was the Society entitled to ask for the help of the medical profession, but the medical profession was really bound to give it, and to give of its best. After all, the medical profession was the guardian, or should be the guardian, of the public health, and the lighting question was one of the most important factors in connection with hygiene. It could not be denied, and he said this advisedly—that illumination was just as much a matter of true hygiene as ventilation or any other sanitary measure. That was absolutely certain, and if the Illuminating Engineering Society could convince the public and the proper authorities of this fact, and could formulate definite recommendations as to what constituted good illumination, it would be doing a work which would be of incalculable benefit to the community at large.

Toast: "Our Guests."

MR. LEON GASTER (Hon. Secretary), in proposing this toast, said he would also like to refer briefly to some letters from friends who were unavoidably absent. Sir James Crichton Browne wrote: "I am following the valuable work the Society is doing." Sir George Kekewich: "I should have been delighted to accept, especially as I take a very keen interest in the lighting of all educational institutions." He might mention, among others who had expressed regret at absence, the names of Lord Rayleigh, Sir Aston Webb, Sir J. Yoxall, Sir H. Tanner, Sir T. Oliver, Sir Geo. Newman, Col. R. E. Crompton, Mr. Patchell, and the Presidents of the Institution of Electrical Engineers, the Royal Institute of British Architects, and the Ophthalmological Society.

There was one point he might mention before proceeding to the subject proper of his remarks. They would notice that the toast list had been somewhat curtailed. This had been arranged in order to leave time for members to converse after the speeches were over, and he hoped members would take advantage of this opportunity before breaking up for the evening.

Proceeding, Mr. Gaster said he was sure all regretted especially the absence of Professor Thompson, to whose services to the Society Sir Boverton Redwood had already made such happy reference. But they were glad to feel, in welcoming Sir William Bennett as the President Elect, that the Society has secured a new friend and that they had been exceedingly fortunate in securing the support of such an eminent member of the medical profession.

They were also fortunate to-night in the presence of Sir W. Crookes who, as President of the Royal Society, occupies what is perhaps the premier position that any scientific body in this country can offer. For many years Sir William has also been closely associated with the Royal Institution, and the recent award of the Order of Merit is surely the best recognition that could be given to the width and originality of his researches. Sir William Crookes was one of the pioneers in molecular physics and in the study of those intricate processes within

the atom on which the production of light is really based. The Crookes radiometer is known to every student of physics. More than once it had been suggested that a direct reading photometer might be based on the same principle; but such an instrument is yet to come. In 1881, Sir William was instrumental in designing apparatus for the production of high vacua, a matter of vital importance in the subsequent development of incandescent electric lamps; and his own house was among the very earliest in London to be lighted by electricity.

The Society was indeed honoured by the support of the President of the Royal Society, whose wide scientific sympathies are famous throughout the world.

Sir Henry Trueman Wood was known to all members of the I.E.S. as the genial and energetic secretary of the Royal Society of Arts, for whose success he has worked so hard and whose interesting history he has recently written in a most fascinating volume. Mr. Gaster added that he had been a member of the Royal Society of Arts for many years and he felt that the education derived from its varied and delightful papers has been of immense value to him. As a Society they owed a great deal to the advice of Sir Henry in the early stages, and to the constant sympathy and support at the Royal Society of Arts.

If the Royal Society has a unique record for the encouragement of pure science, the Royal Society of Arts has done more than any other body in this country to encourage its practical application. Many are the movements which it has originated, which have proceeded to mature and have then been encouraged to independent existence. From the very first the Society encouraged each illuminant as it came forward. The Society's House was one of the very earliest public buildings to be lighted by gas and it was also one of the first to be lighted by electricity. Sixty years ago the Society formed a Committee to inquire into the effect of light on eyesight in connection with various trades, and anticipated much of the work being done to-day.

Mr. Gaster proceeded to remark that there was another field, *the artistic aspects of illumination*, on which much remains to be done.

Only a few weeks ago Sir Aston Webb was advocating the establishment of a Ministry of Fine Arts in this country, and the proposal has received considerable support from the architectural profession. Surely lighting is a "fine art," and he hoped that this will not be forgotten should such a ministry ever be formed.

On the artistic aspects of illumination we have much to learn, and our Society naturally turns to the architects with whom the lighting of buildings of historic and architectural distinction so largely rests. He was glad to welcome as one of our guests Mr. A. W. S. Cross, Vice-President of the Royal Institution of British Architects, and felt sure that the aims of the Society would receive the sympathy of the Institute.

Only a month ago when the Society was discussing the problem of daylight illumination, the design of window space and other matters of vital interest to the architectural profession, Mr. A. E. Farrow, F.R.I.B.A., came as the representative of the Royal Institute of British Architects. He expressed his conviction as to the important work now being done in this direction by the Illuminating Engineering Society.

There were also present to-night several vice-presidents of the Society, including Sir Boverton Redwood, one of the Society's earliest and staunchest supporters, who was present at the Inaugural Meeting in 1909, and who had come again to propose the toast of the Society that night, in spite of other pressing engagements. It was also a pleasure to see present Mr. Edward Allen and Mr. Snell, representatives of the Institutions of Gas and Electrical Engineers, with whom the Society had had the pleasure of co-operating in several matters during the past year. They hoped to continue this friendly co-operation, and he might mention, as an illustration of the cordial relations already established, that it had been agreed for the Presidents of these two Institutions always to be also Vice-Presidents and Members of Council of the Illuminating Engineering Society.

The movement, in short, offered points of interest to all professions, and

he asked them to drink the toast of the distinguished representatives of these professions who were present.

SIR WILLIAM CROOKES, F.R.S., O.M. (President of the Royal Society), said there was a peculiar appropriateness in his rising to reply to this toast, because he was probably the oldest illuminating engineer in the room. His experience dated from the 1830's or 1840's, when he was a boy. He then spent a good deal of time at a farmhouse in the country, and his early experiences in lighting were with the tinder box. At that time also he made sulphur matches, and became very expert in getting a light from the tinder box. After that time came the rushlights and tallow candles, and other primitive methods of obtaining light. He recalled how, when he was in Africa some twelve or fourteen years ago, he found that the method of getting fire was almost entirely confined to the flint and steel. Everybody carried a little apparatus of this kind, and he also heard of some tribes which used the old-fashioned method of getting fire by rubbing sticks together. He was able to get one or two members of that tribe together, and one man showed him how it was done. In two or three minutes they got smoke, and in five minutes a flame. He took possession of these sticks, and when he came back he was able to show his friends how it was done.

Following on the tallow candle came the oil lamp and the gas lamp, and at last came electric lighting, in connection with which he remembered an exhibition on the roof of the Polytechnic, from whence a brilliant light was thrown down Regent Street, much to everybody's surprise. He made a good many lamps of his own at that time, and thought it would not be bad if he lit his house. He excavated a very large hole in the front garden, and put in an engine and dynamo, which had such an effect upon his neighbours that one gentleman gave up his house and refused to come back for fear of being blown up, owing to one of the workmen having confused the words "dynamo" and "dynamite," and having referred to the excavation as being a dynamite factory. At that time he was an experimental chemist, and had a large quantity of hard glass tube in his possession. There was not very much known about insulation at that time, but he knew that glass was a good insulator, and so he laid his wires in this hard glass tube. In this way his house was the first in England to be lighted by electricity, and moreover, he made the lamps himself. That was in 1881, and a few years ago the Electric Supply Company, which now supplied him, made an examination of the insulation on some of the older installations on its system, and it was interesting to note that whereas a great many installations were defective, his glass insulation gave as good a test as could be wished for. He could therefore thoroughly recommend glass tube for electric wiring!

The President had mentioned the importance of the scientific study of lighting, and in this connection he might mention that quite recently he had sent a communication to the Royal Society giving the results of some researches that he had carried out in connection with a Committee of the Home Office on the preparation of glass for spectacles. He had made some two or three hundred samples of glass of all colours, and had succeeded in preparing a glass which cut off all the heat rays, but very little light. Other glasses which he made cut off all the ultra-violet rays, which were very injurious to the eyes, but scarcely impeded the luminous rays. He believed that some of these glasses were perfect in reducing glare from the sun, white cliffs, and from the snow in Switzerland. He hoped that illuminating engineers would continue these researches, and succeed in producing a method of illumination which would yield a more substantial proportion of the valuable luminous rays, but would suppress those that were useless or prejudicial.

SIR HENRY TRUEMAN WOOD (Secretary of the Royal Society of Arts) remarked that whereas Sir William Crookes' house was the first to be lighted by electricity, he believed the Royal Society of Arts' premises was the first public building to be permanently lighted by electricity, and it continued with that form of lighting up to the present time.

The Royal Society of Arts had a very

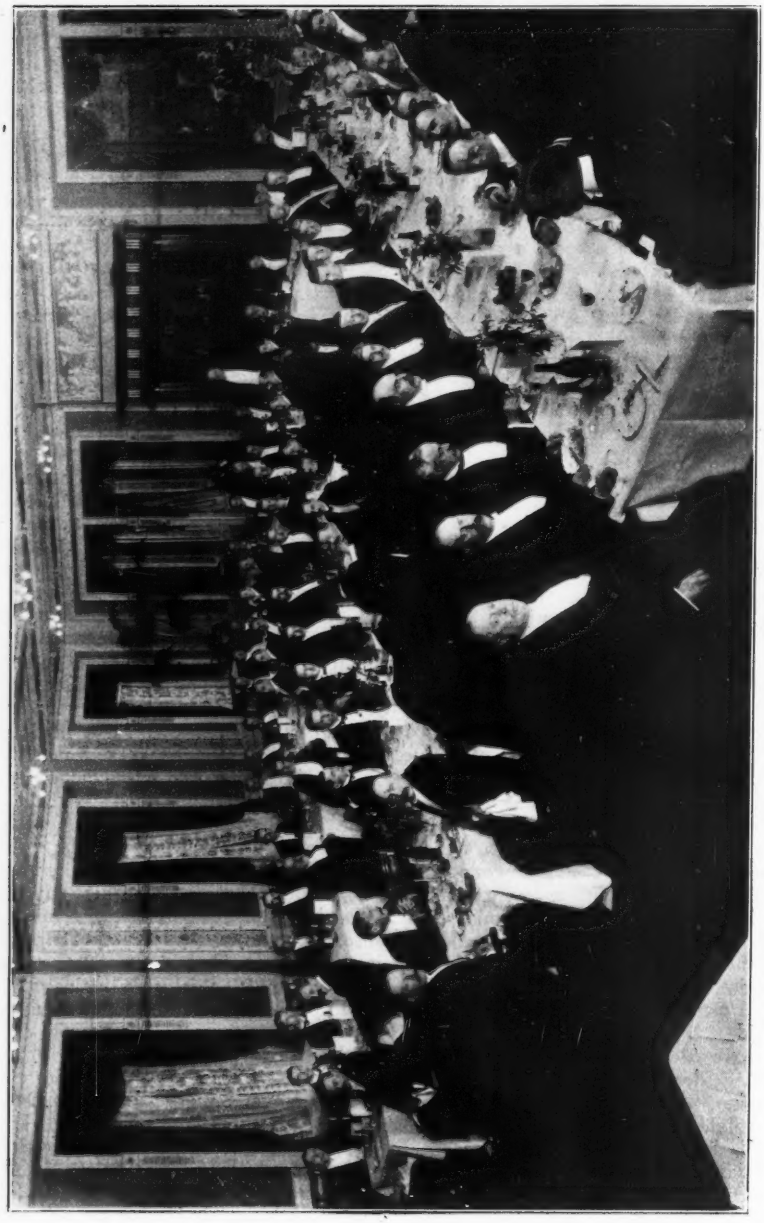

Photo by Messrs. Fradelle and Young, 283, Regent Street, London, W., from whom additional copies may be had on application.

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Mr. H. M. Rootham
Mr. V. H. Mackinney
Mr. R. Lancaster
Prof. D. A. Louis
Dr. A. Gaster

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Mr. J. O. Grant
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Mr. G. M. Lloyd
Mr. J. S. Dow
Times Representative

Mr. F. W. Goodenough
(*Vice-President and Chairman of Council of The Illuminating Engineering Society*)

Mr. Foster Moore

Mr. J. Herbert Parsons, F.R.C.S.
(*Vice-President of The Illuminating Engineering Society*)

Sir Henry Trueman Wood
(*Secretary of the Royal Society of Arts*)

Sir Boverton Redwood, Bart., D.Sc., F.R.S.E.
(*Vice-President of The Illuminating Engineering Society*)

SIR WILLIAM BENNETT, K.C.V.O., F.R.C.S.
(*President-Elect of The Illuminating Engineering Society*)

Sir William Crookes, F.R.S., O.M.
(*President of the Royal Society*)

Mr. A. W. S. Cross, M.A., F.R.I.B.A.
(*Vice-President of The Royal Institute of British Architects*)

Mr. J. F. C. Snell
(*Vice-President of The Institution of Electrical Engineers*)

Mr. E. Allen
(*President of the Institution of Gas Engineers*)

Col. W. F. Leese

Mr. J. Wyatt Ife.
(*Hon. Treasurer*).

Mr. R. J. Wallis Jones

Mr. T. Gaster
(*Hon. Secretary*).

ANNUAL DINNER OF THE ILLUMINATING ENGINEERING SOCIETY,

Held at the Trocadero Restaurant, Piccadilly, London, W., Friday, February 13th, 1914.

(The positions are in accordance with the photograph on the opposite page).

close connection with the Illuminating Engineering Society, for, following its usual custom, it had decided to leave the art of illumination out of its programme when it found that there was a Society strong enough to deal with the matter itself. Having done this, however, it had afforded the Illuminating Engineering Society what help it could in the way of lending its rooms for their meetings.

As a matter of fact the formation of the Illuminating Engineering Society was immediately preceded and no doubt stimulated by a series of most admirable Cantor lectures given by Mr. Gaster before the Royal Society of Arts.

In conclusion, Sir Henry remarked that even in the hall of the Royal Society of Arts the Society had made its influence felt, and had recently induced him to make substantial additions and improvements to the existing lighting.

MR. A. W. S. CROSS (Vice-President of the Royal Institute of British Architects), who made the final reply to the toast, expressed his appreciation of the manner in which the guests had been received, and regretted the absence of the President of the Royal Institute of British Architects, Mr. Blomfield.

Speaking on the architectural side of the illumination question, he said that architects of his generation had not had the advantage of a scientific education in illumination, and had formed their methods before lighting was considered in a scientific way. But they now knew where to turn for expert advice, namely, to the Illuminating Engineering Society, and this was the next best thing to such an education. Therefore, he wished the Society every success, on behalf of the Royal Institute of British Architects, and believed that if the Society continued to flourish, architects would be relieved of a great deal of anxiety.

The present day was an age of specialisation, and scientific artificial lighting was in itself a life-study. Such movements as that being developed by the Illuminating Engineering Society naturally required time to make themselves felt, and no doubt the next generation of architects would go to work on more scientific lines.

OFFICIAL ANNOUNCEMENT OF NEXT MEETING.

(To be held in the House of the Royal Society of Arts, 18, John Street, Adelphi, London, at 8 p.m., on Tuesday, March 17th, 1914.)

At this Meeting a paper will be presented by Mr. W. C. CLINTON on "A COMPARISON BETWEEN ILLUMINATION ESTIMATES AND PERFORMANCE IN PRACTICE."

Tickets can be had on application to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.).

THE LIGHTING OF PICTURE GALLERIES AND ART STUDIOS.

(Discussion at a Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., on Tuesday, Feb. 17th, 1914.)

SUMMARY OF PROCEEDINGS.

A MEETING of the Society took place at the house of the Royal Society of Arts, on Tuesday, February 17th. Mr. F. W. GOODENOUGH was in the chair, but had to leave early and his place was then taken by MR. R. J. WALLIS-JONES.

The Minutes of the last meeting having been read, the names of new applicants for membership were presented.

A discussion on the **Lighting of Picture Galleries and Art Studios** was then opened by PROF. S. P. THOMPSON (see page 148). The following took part:—MR. A. P. TROTTER, MR. DAVID MURRAY, R.A., MR. JOSEPH PENNELL, MR. V. H. MACKINNEY, MR. PERCY BIGLAND, MR. S. E. THORNTON, MR. P. BUSH, MR. JUSTUS ECK and MR. T. E. RITCHIE.

A vote of thanks to Professor Thompson was moved by the CHAIRMAN (MR. R. J. WALLIS-JONES), who also referred to the courtesy of Mr. A. B. Macdonald, of the Public Works Office in Glasgow, and of Mr. W. T. Oldrieve, architect to H.M. Office of Works in Edinburgh, for the information and photographs relating to the McLellan Gallery and the Royal Scottish Academy; and to those firms who had contributed to the success of the evening by sending exhibits.

In conclusion, the CHAIRMAN announced that the next meeting of the Society would be held on **Tuesday, March 17th,** and a paper by PROF. W. C. CLINTON entitled **"A Comparison between Illumination Estimates and Performance in Practice."**

NEW MEMBERS OF THE SOCIETY.

THE names of applicants for membership read out at the previous meeting on Jan. 15th* were formally announced at the last meeting, and these gentlemen declared members of the Illuminating Engineering Society.

In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were also read out by the Hon. Secretary at the last meeting:—

Vice-President and President-Elect:—

Bennett, Sir William, K.C.V.O., F.R.C.S.	Member of Consulting Staff of Osborne, H.M. Inspector of Anatomy, Consulting Surgeon to St. George's Hospital, &c., 1, Chesterfield Street, LONDON, W.

Ordinary Members:—

Anderson, L. S.	Asst.-Engineer, Lancs. Electric Power Co., Westerby, Westmorland Road, Urmston, N. MANCHESTER.
Bryan, J. H.	Consumers' Adviser, St. Pancras Electricity and Public Lighting Dept., 57, Pratt Street, LONDON, N.W.
Green, H. N.	Lighting Dept., General Electric Co., Ltd., 34, Lansdowne Gardens, Stockwell, LONDON, S.W.
Laurence, E. F.	Elec. Engineer, 131, Sefton Park Road, BRISTOL.
O'Connell, M. W.	Sec. and Director of Pope's Elec. Lamp Co., Ltd., 18, Meall Road, Harlesden, LONDON, N.W.
Snelson, E. D.	Draughtsman, 16, Baltic Street, Seedley, MANCHESTER.

* *Illum. Eng. Lond.*, Feb., 1914, p. 73.

THE LIGHTING OF PICTURE GALLERIES AND ART STUDIOS.

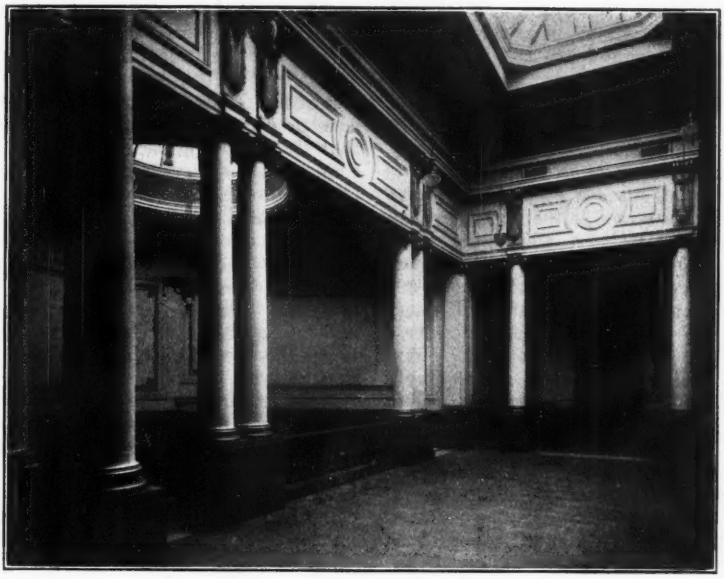
(DISCUSSION AT A MEETING OF THE ILLUMINATING ENGINEERING SOCIETY HELD AT THE HOUSE OF THE ROYAL SOCIETY OF ARTS, 18, JOHN STREET, ADELPHI, W.C., ON TUESDAY, FEB. 17TH, 1914.)

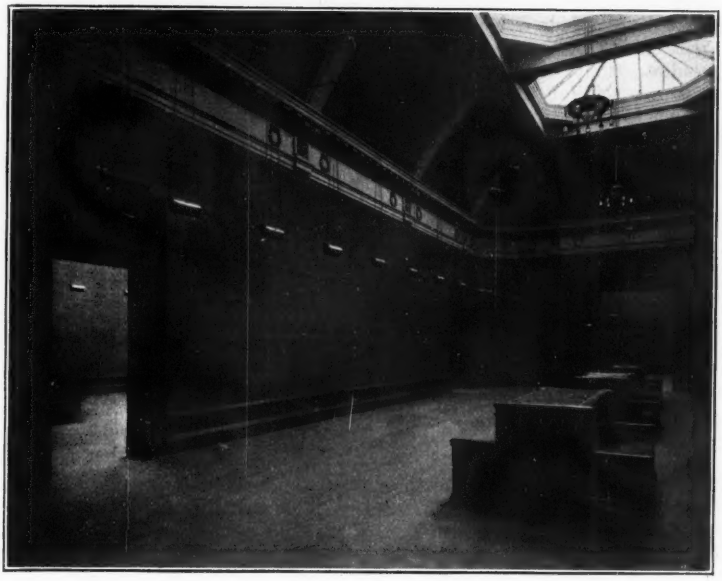
PROFESSOR SILVANUS P. THOMPSON, who opened the discussion, said that the Illuminating Engineering Society dealt with lighting in its most general aspect, and also with lighting in its particular applications to special cases. At former meetings they had discussed the lighting of schools, of libraries, and of public buildings generally. The members had met always on the common understanding that they did not go out of their way to press this or that particular illuminant, but tried to find a common ground for gas, electricity, acetylene, daylight and everything else, endeavouring at the same time to lay down useful rules which governed the production of the satisfactory illumination of surfaces, tables, walls, pictures, or whatever it might be, by whatever means. But the lighting of picture galleries and art studios had never been discussed by the Society in any detail. An endeavour had been made on this occasion to secure the assistance of a number of gentlemen particularly interested in the lighting of galleries and studios, and his own task was simply to lay down a number of points, as it were, more or less debatable, in order to elicit information, criticism, and suggestions, and to get at the experience of those who were in the best position to know.

He would begin by taking the question of daylight lighting. In every picture gallery there must be windows of some sort, and we wanted to know what is the best disposition of windows, and how the disposition of the apertures which admitted the daylight might be made the most effective for the purpose. It was presumed that for the majority of galleries the surface to be illuminated was a vertical surface, against which pictures were hung. There were, nevertheless, plenty of cases of horizontal surfaces, where works of art were frequently displayed, or for the lighting of sculpture, and in these cases different conditions prevailed from those relating to the lighting of walls.

One principle could be laid down for the lighting of art galleries where things were to be displayed on the walls, and he laid this down as a general principle, viz., that there ought to be a superabundance of openings for the daylight to come in. If there were an insufficient admission of light the pictures suffered. If there was a superabundance of daylight this could always, by the aid of screens, be diminished. Architects ought to have impressed upon them this condition, *i.e.*, that there should be an abundance of top lighting, because as a general rule, with pictures all round a room, any side lighting was disastrous to some part of the aspect of the place. He thought he could say that he had not seen any satisfactory art gallery where the height of the openings through which the light came was not such that the slope of the light from the opening to the pictures was lower than 45 degrees. The lowest part of the openings ought to be 45 degrees above the level of the picture, otherwise the people standing a few feet away got the direct reflection, the specular reflection, from the glass or varnish, due to the openings that were too low.

Then again, for the light of galleries where pictures were hung on the walls, it was a matter of considerable importance as to what was done with the rest of the wall between the tops of the pictures and the place where the windows or skylights began. Some picture galleries were designed as if that space were of no importance. On the contrary, it was of very great importance to have an adequate space between the top of the pictures and the beginning of the light openings, and to have that space rightly occupied, because when direct light was coming in through an opening a great deal





Two views of the new McLellan Gallery, Glasgow, showing lighting from the roof and local artificial illumination.

of that light—even possibly direct sunlight—was received upon the sides of the walls, and these gave out light by diffuse reflection in all directions to the pictures. If this upper wall space was unsuitably occupied, then the pictures opposite suffered. The picture on the right-hand wall received some of the light from the wall on the left, and *vice versa*. A very remarkable example of misjudged treatment of wall-space was afforded by one of the largest rooms, the Turner room, in the Tate Gallery, where the space above the pictures up to the skylights was a strong crimson tone; with the result that when the light was coming in through the skylights and struck on that crimson wall, all the pictures opposite were illuminated by a red light, and not by a true daylight, and they were ruined in some aspects. If any persons happened to be in that room in the Tate Gallery on a bright day, with fleecy white clouds and occasional alternations of bright sunshine and shadow, so that the red wall was lighted up brilliantly and then plunged into comparative darkness, they would observe that the pictures absolutely changed colour. The effect of colour on the reflecting walls opposite had not been sufficiently considered, at any rate, in that particular case.

For studios, things had crystallized almost into a regulation that an artist's studio ought to have a top light, and possibly a window in combination with it, facing towards the north, in order that there might be no trouble with direct sunlight, and so that the light of the sky might always come diffused through that window. It was not, however, always desired to have the light in the same direction, and artists would be well advised if they had what he had mentioned before, namely, a superabundance of glass, so that they might shut off by curtains more of the light to the left or to the right, as suited the particular case.

He would deal next with artificial lighting. What was the right position in picture galleries for the placing of the artificial lights, and why do we want artificial lights? What was the particular object of these lights? Was it to give a general illumination for the walls of the room, or was it to light up particular pictures? Both, it might be said, occasionally; and obviously an arrangement of lamps which might be good for general illumination was not one which could be adopted for lighting particular pictures.

One rule probably might be taken almost for granted, that whenever lamps were used they ought to be so screened that there were no interfering reflections from the glass or varnish of the pictures coming direct to the eyes when one was standing in the right position to see the pictures. Lamps must be so screened that they did not interfere with the proper viewing of the pictures. The extremest mode was to employ indirect lighting, to allow no light from the lamps directly to fall upon the pictures, but to cause the lamps themselves to throw light on to some wall or ceiling or screen which would diffuse the light in order to obtain a good general illumination. It was now common even in ordinary halls to have concealed lamps which throw their light on to a wide cove or cornice, or a portion of the ceiling, so that there might be no shadows, and so that the light might be diffuse instead of appearing to come from distinct bright points. For certain purposes, such as engineering drawing offices, it was admirable to have this indirect lighting; but it was not satisfactory in many cases for an art gallery. There always seemed to be something wanting if the lighting was only indirect, especially so where one desired not simply to illuminate the walls, but to illuminate objects down below, as for sculpture galleries, where a great part of the beauty and effect of the sculpture depended on the shadows; here one did not want shadowless lighting.

He would like to lay this down as a challengeable proposition, that as regards the position of lamps in picture galleries or studios, they ought to be placed so that the main direction of the light they give is the same as the main direction of the light that comes in all day through the windows, in order that there might be the same direction in the two cases. This had been found to work well in certain cases. For example, there was an exceedingly good new art gallery in the Royal Scottish Academy, having a number of interesting features. The

entrances, for instance, were not, as usual in most galleries, at the middle of the side of the wall, but they were at the corners ; a plan which enabled the hanging of the pictures to be carried out on a consistent scheme. In that gallery there was a suitable vertical wall space above the height of the pictures. Then there was a coved surface above, and at the top were the skylights through which the light came. The angle at which the light came from the lowest part of the skylight to the top of the pictures was just a little under 45 degrees. Furthermore, the artificial lighting by lamps was by groups of lamps put all round the sides and across the skylight, so that the direction of the lighting was the same by night as by day. He had no doubt of the great advantage in the visibility of things in that room. He would like to lay down for artists' studios also some rule that as far as possible the natural and artificial lighting should be done from the same direction.

Many years ago he had the honour of being consulted privately by one of the most distinguished artists of the present day, who was now in the Academy, for advice as to the lighting of his studio in order to get a little prolongation of the daylight in the afternoon. There were not the means then which exist now, and he recommended him to have two arc lamps, the best that could be obtained, and to fix them up quite high close to where the north light was, and to turn these arc lamps on at least half-an-hour before daylight went. He advised his friend that he would then not know that the daylight was gone, even after he was working only by artificial light. He now regarded that as an extremely imperfect way ; but it enabled the artist to go on with his work. This brought him to the really more important question, namely, the colour of the artificial illumination.

It had been an objection to all artificial illumination that its colour was so different from that of natural daylight. Perhaps those who complained bitterly about the bad effect of pictures due to the tints of gaslight, electric light or acetylene were not all aware how extremely different daylight could be from daylight. The morning light, when there was a blue sky with white fleecy clouds, was of a totally different tint from the afternoon light, when there was a light mist about, or, as in London, with smoke. Then the colour of the sky was quite different. If we were to succeed in matching a morning sky with artificial light we should not be matching an afternoon sky. We could not match all these things at once. Nevertheless it was possible even now to do a great deal in the way of approaching the tint of daylight with an artificial daylight. This had been tried in many cases with gas or electric lamps and coloured screens of tinted tissue paper or of tinted silk, which had been hung in front of the light ; but there had always been a considerable hesitation on the part of those who used the lights to employ adventitious aids, because there was trouble in managing the coloured screens, which were not always successful. A silk shade would fade, whilst a glass one was brittle, and it had to be fixed in a frame.

With arc lamps, similarly, screens of various kinds of material could be used to keep down the tone or to subdue their light. In this way a good deal had been done of late years in arranging an artificial daylight for the matching of colours. This had come about from various sides. In Bradford, for example, where the textile industries prevail, a great deal of attention had been given to the question of colour-matching by artificial light. Professor Walter Gardner, of the Technical College of Bradford, and some of his associates, had made many experiments to try and find a form of screen which would give them a light by which they could match the colours of fabrics. Professor Gardner had sent him three fabrics, one a kind of dull purple, another a dull green, and another a piece of shot velvet, as the three most difficult things for testing a lamp as to whether it gave natural illumination. These were all dull shades, and the primary tints in them were not so very far from balanced ; the resultant tone preponderating in favour of purple in one and green in another ; and if these were examined by lights that differ comparatively little from one another in tint, there was nevertheless a great difference in the apparent tint of the

fabric. Professor Gardner had devised a practical lamp with a shade made of a particular blue glass obtained after many experiments and much expense, containing cobalt and copper in its composition. These lamps were being used extensively in colour-matching in the factories of Bradford and Huddersfield. Then again, the Allgemeine Company, of Germany, had brought out a lamp of a somewhat similar kind for the same purpose, giving practically a white light, but they had designed it in a different way. He had not seen the lamp, but he believed that it consisted of an arc lamp within a lantern glazed with a curious mosaic of coloured glasses, in which blue was slightly prevalent, and outside that again there was a diffusing screen of glass with ribs or corrugations on it to mix up the mosaic of tints and give a diffused white light. Several forms of enclosed arc lamp had also been devised to work with very long arcs—an electrical device which enabled the distance between the tips of the carbons to be unusually long. The lighting that came from that lamp consisted, as in all arc lamps, of light sent out by the white-hot carbon, but in these particular lamps with long arcs the blue of the arc was somewhat more in excess than was the case in open arc lamps; so that the light of these particular lamps somewhat approached daylight.

On the other hand there were some illuminants, notably the Mercury Vapour Lamp, which yielded light of such a peculiar colour as to be quite out of the question in any case in which the appearance of coloured objects was important. The same applied to some early forms of incandescent gas mantles, which after a time had a greenish tint.

There had recently been a number of suggestions, which constituted a distinct step in advance, to construct tungsten filament electric lamps in bluish bulbs, instead of the usual bulbs of white glass, thus avoiding the need for any other screen. In this way it was becoming an exceedingly simple matter to bring artificial daylight into the gallery or studio by merely grouping the lamps in the proper place, and adopting these lamps with the blue globes. Experiments in the same direction with incandescent gaslight had been carried out by Dr. H. E. Ives, in the United States, and by Mr. T. Thorne Baker in this country.

Although this was a distinct step in advance, there remained a very great deal more to be done, on account of the extreme complexity of the colour question. He did not know whether all artists realised that for colour matching there was a great difficulty with certain greens, which changed their apparent tint with comparatively little change in the quality of the light falling upon them. He could not explain this, but believed it was inherent in the nature of things, and if it were possible to properly illuminate the greens in order to match them satisfactorily, we should then have attained a real daylight lamp. The dull greens, so fashionable at the present time, were curiously sensitive. If they were exposed to different lights they seemed quite different. Such greens were, of course, mixed tints; this kind of green was very far from being a saturated green; it was rather a neutral green, and any little change in the light—a little redder or bluer—showed itself immediately. From a nearly balanced condition of things, any slight inequality in the composition of the light created very different colour effects. He did not know whether any of the members of the Society were acquainted with one of the rare minerals, sometimes regarded as a gem, a species of dull emerald, found in one of the mines in the Ural Mountains, belonging to the Imperial family of Russia. It was called the Alexandrite, and he had a sample with him. The Alexandrite has this strange peculiarity: by daylight it was green, but at night it was a kind of claret colour. If we could only find a light which could stand the test of an Alexandrite, such a lamp would be a good one for the lighting of studios. Mr. Trotter, who had studied the phenomenon of the brightness of lights from end to end, had given a good deal of attention to this question of imitating daylight. He had examined all the colours of the palette under the spectroscope, when illuminated by daylight and by artificial light, and would explain later on his ingenious apparatus for comparing tints under different illuminations, and would deal with the fact that certain pigments absorb certain bands of the

spectrum, a fact which adds continual complication to the problem, and so makes colour-matching a very difficult question.

He had tried in this short account to state what he thought to be the main points to be brought out in the discussion on this matter, and was quite content so to leave the subject without pronouncing any further ill-founded opinion of his own. He asked them to take the questions that he had put forward and help towards a solution of the difficulties. The Illuminating Engineering Society existed to solve the practical problems of the day in respect of illumination, and it asked to be helped and guided in making known, if they could be made known, any reasonable rules for the better lighting of art galleries and artists' studios.

THE CHAIRMAN said that Professor Silvanus Thompson had often placed the Society under a debt of gratitude, but on no occasion had he done so more than that evening. They all knew that whether he presented a written paper or whether he spoke from the profundity of his knowledge upon almost every subject, they would have a most fascinating and interesting discourse.

Before declaring the discussion open he would like to mention that this was the last occasion upon which Prof. Thompson—for the present, at any rate—would give a paper as President of the Society. For some time the Professor had felt that his period of office had been sufficiently prolonged, and that it was desirable to extend the influence in other directions and to secure the support of an eminent member of one of the other interested professions. At the present moment it was specially desired to enlist the sympathy of the medical profession, and as some of them were already aware, Sir William Bennett, one of the King's surgeons, had intimated his willingness to take up the Presidency of the Society. The Council had decided to extend that invitation to Sir William Bennett, and to ask him to take the Presidential Chair when Prof. Thompson gave it up at the Annual Meeting in May.

MR. A. P. TROTTER said he would like to see discussion turn upon the general lighting of galleries from the architectural point of view and from that of those Keepers and Directors of galleries who were concerned with the results which the architects had endeavoured to produce. There was a good deal of difference of opinion about the lighting of art galleries, and it was apparently very largely a question of the proportion of the rooms, as well as the actual positions and areas of the windows. He believed it was generally admitted that the new rooms in the National Gallery were unfortunate in the disposition of windows, not only from the amount of light, but from the inevitable reflection from those pictures which were glazed.

The Society had discussed very carefully the lighting of schools and libraries, but the lighting of picture galleries could very well receive further attention from architects, and might, perhaps, be studied by a committee of the Society similar to those which had considered the other matters. He agreed that the lighting by lamps should be in the same direction as the light coming from windows, unless, as often happened, the positions of the windows were bad, and in that case it was possible for the artificial lighting to be so arranged to give a better effect. The effect of red walls in the Turner room at the Tate Gallery he could bear out from his own experience. He had seen the tones change, as the President had described. When the rooms were high with an expanse of wall above the pictures, the colour, whilst not being a white, should be as pale as possible.

With regard to the lighting of studios, a north light was, of course, the best light for a colourist, but it was not a constant light. It was obvious that with a perfectly bright blue, clear sky, the light received through a window was blue; nobody would admit it, but it must be so, relatively to true white; and, perhaps, this was not realised until a white cloud bathed in sunshine drifted by. Every artist knew that under these circumstances the light and the colour of the light was continually changing. Nevertheless, we were so accustomed to imagining that the light we get by daylight is white that we were continually deceiving ourselves into that belief. It was quite possible,

experimentally, to cut a piece out of one day, and look at it by the light of another day and match it with a colour.

Mr. Ritchie, some time ago read a most interesting paper before the Society upon colour-matching, when the elements of this question were discussed. On that occasion, he (Mr. Trotter) showed an apparatus that he had made with the idea of getting a colour-screen which would absorb the necessary amount of superfluous yellow, orange and red light obtained from artificial lamps. In a paper which he read before the Institution of Electrical Engineers (Vol. XXI., 1892) he reproduced the luminosity curves of the spectra of sunlight, of the arc, and of gas light, according to Abney and Festing, and by subtracting the ordinates of one from the other he obtained the difference, which indicated the absorption spectrum of a filter. The difference between the spectrum of the sun and of the arc was small, and a pale blue glass of the right colour would suffice. The difference between sunlight and gaslight was very large. The latter gave a great excess of yellow and orange light which would have to be filtered out by deep bluish green glass. But with modern metal lamps the difference was not so great, and it would be possible to produce a good white daylight with a loss of about half the light, while the light of a warm July afternoon could be obtained with greater economy. The last words of that paper were: "I hope to follow up the matter during the summer." Twenty years elapsed before he did anything more, and then he took it up with the idea of trying to produce a screen such as Prof. Thompson had spoken of, which would so cut off the superfluous rays from the modern type of metal filament lamp that it would give practically daylight. He had made a box (which he exhibited), divided into two compartments by a partition in which there was a window. Various samples of glass could be placed at this window. An electric lamp in one smaller compartment illuminated the other larger compartment, through the window. In the larger compartment a cardboard disc, with a number of specimen water-colour tints, was placed. This was illuminated with the light filtered through the window. Outside the box there was another set of tints identical with those inside. The set outside was illuminated by whatever kind of daylight there happened to be. A hole in the box permitted the inner tints to be seen alongside the outer tints and the two could be compared. If a suitable coloured filter could be found the two sets of tints would be identical. Messrs. Winsor and Newton had kindly supplied him with a large number of specimen tints.

He had been trying to get a glass which would give the right screening effect. He had very little time to go into this work, and no opportunity at all of going into the commercial side. He therefore asked various makers of glass for samples. The first samples were cobalt glass, but the spectrum was one with bands across it, which made it hopeless for matching blues and greens. He tried various glasses, but much to his regret found that very little interest was taken in the matter by the glass makers, and his experiments stopped. He hoped to take it up again, but all he could do was to test any samples of greenish-blue glass he could lay his hands upon.

Since the paper by Mr. Ritchie, the coloured lamps referred to by Prof. Thompson had become available, and this was a step in the right direction. He had taken the Winsor and Newton colours and compared them by two "daylight" lamps, A and B, by different makers on a fairly dull grey day, and although both these lamps were so-called imitation daylight lamps, the difference in their effect upon the various colours formed a most interesting study.

The following is the result of these two lamps with the blue tints:—

Daylight.	A.	B.
Intense blue ..	S. green	S. purple
Indigo	,,	S. green
Prussian blue ..	,,	,,
Antwerp blue ..	greenish	greenish
New blue	good	violet
French blue (ultramarine)	S. violet	strong violet
Permanent blue (do.)	good	violet
Cyanine blue ..	greenish	greenish
Leitches blue ..	,,	,,
Cerulean blue ..	,,	,,
Smalt	good	violet
Cobalt	pale	pale violet

NOTE.—S. means slightly.

In the case of the blues, a fight was going on between the violet and the green; in the case of the greens, the contest seemed to be between yellow and brown. Dull greens like *terre vert* lost all their green and turned into a dirty grey under any "daylight" lamp that he had used. It was evident that of these two lamps, A was the better one, and it had a greenish colour, while B was inclined to a purple blue. The reason for the peculiar behaviour of the different tints could only be explained by spectroscopic analysis, and an examination of colour washes on paper in this way presented considerable difficulties.

Many writers had given the ranges of different colours of the spectrum. Sir William Crookes in a recent paper on glass for absorbing ultra red and heat radiation had given the various wave lengths and the proportions of the spectrum containing the different colours. He (Mr. Trotter) had turned these into percentages, and they came out as follows:—

Crookes Phil. Trans. Roy. Soc. V. 214 A. p. 4:

	Per cent.
Red	..22·2
Orange	..17·9
Yellow	.. 8·65
Green	..24·6
Blue	..10·7
Indigo	.. 8·9
Violet	.. 7·8

The point was that the yellow being in a very small proportion and yet the most luminous colour in the spectrum, or that from which the greatest amount of light was received, any of the screens which had absorption bands near the yellow were apt to give difficulties when one came to select screens for daylight purposes. Cobalt glass was ruled out at once on account of the complication of its spectrum. It was difficult to find any literature on the material with which glasses are coloured. He knew that copper would make a glass a greenish hue, and Messrs. Powell kindly made him a small quantity of blue glass coloured with copper, but rather too pale for the purpose. It was impossible to get the right thickness to give anything like the white light. The light turned from yellow to green without passing through white, and on looking at the spectrum of a copper glass it would be found that it cut off the red and then made a sudden drop; in other words, it cut off the spectrum just where the difficulties began. He hoped he would induce glass makers to see the important business which could be done with a glass which could be made, not necessarily in globes, but in sheets, which could be placed in front of lamps in a picture gallery or in a studio, and which would produce something which was a far better approximation to artificial daylight than we had at present.

MR. J. S. DOW (Assistant Honorary Secretary) then presented a communication from Mr. M. Luckeish (see pp. 157-162).

MR. DAVID MURRAY agreed that the Turner room at the Tate Gallery had been dealt with in an unscientific manner from the point of view of lighting, and said it was astonishing to him that nobody had offered remonstrance in the newspapers against the continuance of this extraordinary effect. There never was a finer collection of pictures so successfully "destroyed" as in that gallery. He wondered what poor Turner would say if he had been able to visit that room. As a matter of fact things were no better in the National Gallery, where all the beautiful qualities of Turner sank ashamed of their environment. This was a truth which should not be lost sight of, but it did not pertain to the lighting of the gallery so much as to the suitable decoration and arrangement of the colour scheme. For a long time he was convinced that the worst lighting of any gallery in the world was that of the Royal Academy, which, from every point of view, was a false lighting. He had been instrumental in improving the conditions there after two years of hard fighting and, for the time being, the loss of his dearest friends, who became his antagonists. The use of glass on the pictures had resulted in the argument being used against him that the reflection so created rendered it necessary for a person to twist his head in all directions in order to see the picture properly. His reply was that this was a false argument inasmuch as it compelled a person

to look at a picture from all angles and so really appreciate all its qualities, instead of being able to pass it by with a look over the shoulder as was so often the case.

He agreed with Prof. Thompson's suggestion that for studios the more light that could be introduced the better, and north light was the best, as there was no light steadier than that. The question of colour had been interesting him. He had never painted a blue sky out of doors without feeling convinced he was securing the finest blue sky he had ever managed, the next morning he was compelled to the belief that he had done nothing of the sort; the reason for this was, he believed, that the blue sky which was being attempted was actually reflecting its own blue upon the artist's slimy surface and gave a pigment tint temporarily which the artist had not in his box. In this way was the artist deceived as to his true colours even in daylight, and the blue lamp was doing something of the same sort, it gave a fictitious beauty. Nevertheless he looked forward to further improvements in these daylight lamps, and hoped they would be available in their most perfect form before very long.

MR. JOSEPH PENNELL said he did not think there was the slightest relation between the lighting of a studio and the lighting of a picture gallery. The studio was a place one wanted to work in and to get the best effect possible, whereas a picture gallery was a place where one wanted to make one's work tell as well as possible. Thus the conditions were altogether different. The old north light idea was an idea which he thought had been played out long ago, until he heard Mr. Murray say he liked it. Many distinguished artists cared nothing about north light, but they cared about the light which they arranged to come into the place where they were working, and no artificial light could come near it. Prof. Thompson had said he had advised a series of arc lamps which would prolong daylight. That was a very interesting thing to him, because he did not believe it was possible to imitate daylight with any great degree of precision. Some artists used electric light; but those who were not colour-blind did not use it to prolong daylight, but when they used it painted the entire picture by it. It was nonsense, artistically, to try to combine the two lights in one work.

Whistler years ago showed how to light galleries. The whole thing was perfectly simple. In order to do so a screen, which could be raised and lowered according to the condition of the light, was hung under the skylight so that the light fell on the pictures only. That was all that was necessary to obtain perfect lighting in a picture gallery. At night the lights should be arranged on top of the screen so that they could not be seen, and their light would be thrown on the walls in exactly the same way. That was the whole problem, which had been already solved, but it seemed impossible to get most architects or artists to see it. If they adopted this plan it would enable them to prolong the time by which pictures could be seen by daylight and show them much better by night, and incidentally to obtain many more shillings from the public. This method had been installed in Venice and in Munich. The screen must be raised or lowered with the sun, and it must be capable of being shifted several feet. It was not, however, a good thing for a Society show, because everybody underneath the screen looked perfectly black, but it was a good thing for a picture show where, after all, pictures were what people were supposed to want to see.

(*To be continued.*)

[*Several additional communications having been received since the date of this meeting, it has been decided to publish the remainder of the discussion, together with Professor Thompson's reply, in the next number.—Ed.*]

THE LIGHTING OF PAINTINGS.

By M. LUCKIESH.

Physical Laboratory of the National Lamp Works of General Electric Co. (U.S.A.).

No more interesting field is open to the lighting specialist than the lighting of paintings. Here is a neglected field offering opportunities for the application of the knowledge of the science of light as it affects light, shade, and colour. Success lies in applying this knowledge with an appreciation of art and the co-operation of the artist. The latter can perhaps be best obtained by actual demonstration of the principles which we know to exist. Observation reveals the fact that little scientific knowledge has been applied and in general not much care has been exercised in the lighting of paintings. For this reason and for the purpose of convincing the artist that science can overcome some of the handicaps of ordinary illuminants and pigments the writer was led to experiment rather extensively in the lighting of works of art.

Obviously the mode of attack involved the study of the influence of lighting upon light, shade, and colour. There are certain physical facts which appeal at once to one familiar with the science of light and lighting. For instance, in the matter of reproducing extreme ranges of light and shade pigments have quite the same limitations as the photographic plate. A scene in Nature when explored with a brightness photometer often exhibits a range in contrast or light and shade (from the sky to the deepest shade) of 500 to 1. Pigments being luminous only by reflected light cannot reproduce a range more than 70 to 1 in the extreme case and usually much less in practice when under the same illumination. Of course, the artist employs illusion to overcome partially certain handicaps. Experiments have shown that it is possible to illuminate paintings by means of local units in such positions as to assist the artist in overcoming this initial handicap. This is illustrated in Fig. 1 as well as the limitations of photographic reproduction will permit. Definite moods are expressed or suggested depending upon the position of the light source. In lighting this painting by means of a local unit placed near the upper right-hand corner the original range of contrast found in the actual scene is more nearly approached, thus assisting the artist in his effort to reproduce the original mood or expression. The lighting artist should not attempt more than this. In Fig. 3 is shown Hoffman's Christ in Gethsemane lighted predominantly from a unit near the upper left-hand corner. The accentuation of the effect of the beam of light is unquestionable. This method does away with general lighting in art galleries which is often the real cause of dissatisfaction. The discussion which follows further condemns general lighting.

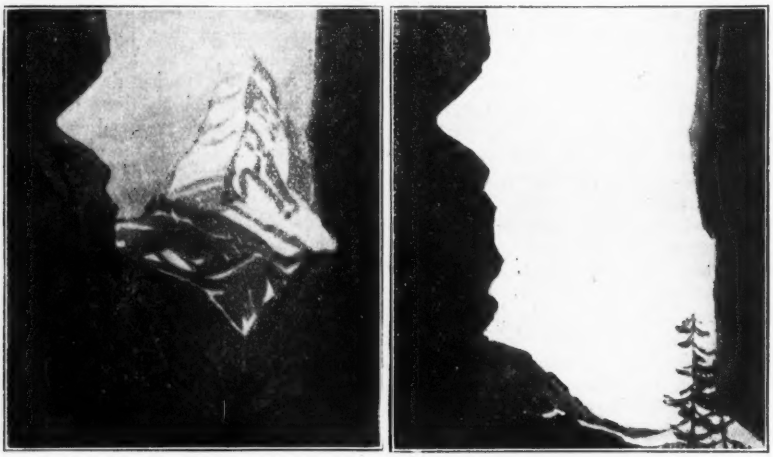
It is well known that the quality or spectral character of light plays a highly important part in the appearance of coloured objects. The appearance of coloured pigments under daylight and artificial light are usually quite different. Even daylight varies tremendously with time and place. Colours are also greatly affected by the intensity of illumination. Paintings are executed under various conditions of lighting, and there is therefore but one proper lighting for each painting. If the production of a painting involves great skill in the proper combining of intricate variations of colours in respect to hue, saturation, and brightness—and it surely does, for colour is the very essence of painting—then the illumination of the product is highly important from the various view-points of intensity, colour-value, and distribution of light.

For years paintings were nearly always viewed under daylight illumination, but to-day this is not true. The daylight appearance (not always correct by any means) has thus become the standard. In order to give paintings a daylight appearance it is possible to produce

Note how local lighting increases brightness on the left, giving more sombre effect in top right-hand corner.

Uniformillumination, general, somewhat flat, effect and uniform white sky.

FIG. 1.—INFLUENCE OF DIRECTION.



Alpine Evening view illuminated by white light.

Same picture lighted by orange-red light. The distant mountain is no longer seen.

FIG. 2.—INFLUENCE OF COLOUR.

Effect of Colour and Direction of Light on the appearance of Illuminated Pictures.

artificial daylight.* The means adopted by Ives and the writer is expensive and unnecessary in this case. The writer's experiments have shown that it is possible to correct paintings to daylight appearance by adding to ordinary artificial light those rays which are demanded by the painting under consideration. Some paintings need not be corrected, many will require blue rays, others blue-green, and in some few cases it is found to be legitimate to actually add yellow rays owing to the fact that pigments are sometimes dimmed by time. Some of Turner's atmospheric paintings and those of Inness were especially enhanced by treating them conservatively with yellow rays. The coloured rays can be added conveniently through the use of coloured glass or coloured incandescent lamps. Most pictures will, of course, require greenish-blue rays or blue rays. The delicate

FIG. 3.—Hoffman's "Christ in Gethsemane" illuminated by combination of white and greenish-blue light.

effects produced by thus adding the proper rays to the ordinary artificial light cannot well be illustrated by means of photographs. A beautiful effect was produced by treating Hoffman's painting (Fig. 3) with greenish-blue rays added to the uncoloured artificial light.

The effect of quality of light on a painting is well illustrated in Fig. 2 by means of a specially painted picture.

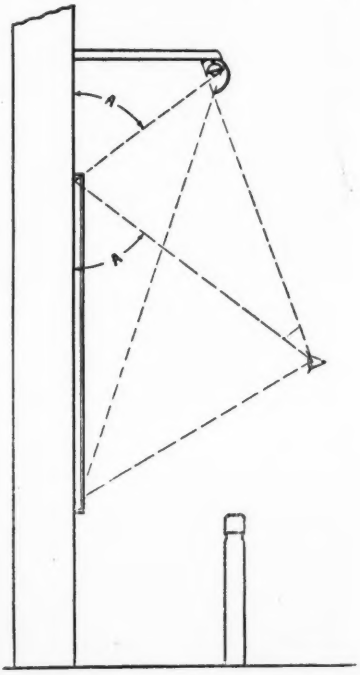


FIG. 4.—Showing details of arrangement of reflector and lights; specially coloured lights are selected for each picture.

Under an orange coloured illumination the mountain and objects in middle distance have completely disappeared. In many paintings the effect of injecting rays of proper colour gives the picture an atmosphere quite lacking under artificial illumination.

In the lighting of paintings the writer heartily endorses the specific treatment of each picture with light properly distributed or directed and of carefully chosen colour-value and intensity. This is an easy matter when treating lone paintings but becomes more difficult in large exhibits where pictures must be crowded together in utter and often

* (London *Illuminating Engineer*, July 1911). *Electrical World*, May 4, 1911.

FIG. 6.—How pictures should *not* be hung.

FIG. 7.—Satisfactory hanging of pictures where wall space is limited.

involuntary disregard of the best principle of hanging. But, after all, the lighting specialist can suggest proper hanging from a view-point quite unfamiliar to the artist. The treatment of a large exhibit as outlined above can be done with a degree of satisfaction by such a means as shown in Fig. 4, which is the method adopted by our Engineering Department in applying these principles of lighting to a large temporary exhibit where the writer had an opportunity to correct the appearance of the paintings. installation received much favourable comment, which is indicative of a new era in the lighting of paintings in this country. The light reflected from the walls was sufficient for general purposes, and there was no annoying reflection from the glass coverings, excepting in cases where paintings were hung higher than agreed upon. Even in these cases it was sometimes possible to avoid annoying reflections owing to the flexibility of the arrangement of lamps. In Fig. 5 is shown a partial view of the French

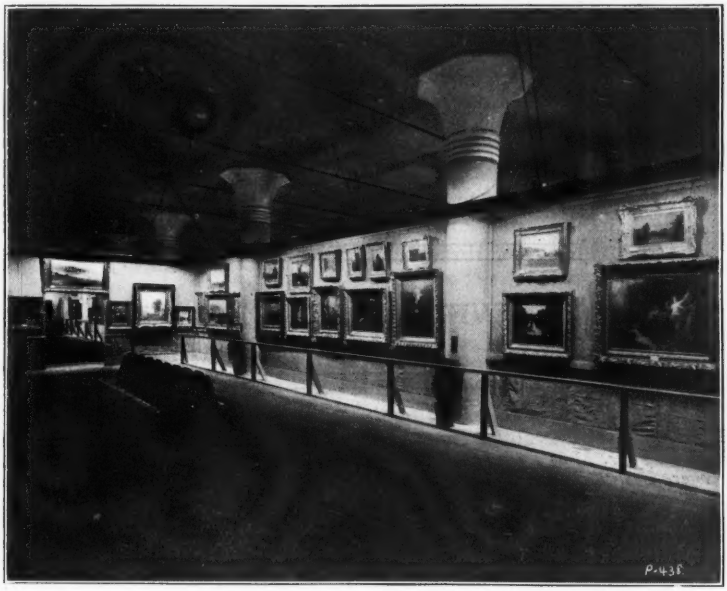


FIG. 5.—Partial view of French room containing several Corot pictures.

Incandescent lamps were placed in close-fitting scoop reflectors shielded from the eye by a continuous trough. The scoop reflectors were adjustable so as to send the light where desired. The majority of lamps used were clear lamps, and the coloured lamps were carefully selected for each painting. The magnitude of this first actual installation is illustrated by the 900 feet of trough and 400 coloured lamps which were used. Improvement in fixtures can no doubt be made, but this method was adopted as a most feasible one for this first trial, which was a temporary exhibit. The room in which several Corot paintings and a number by Millet received special comment. While the paintings are crowded together in an unsatisfactory manner special treatment for colour-value was quite possible. Fig. 6 is a good illustration of how paintings should *not* be hung. Fortunately this condition did not prevail at the exhibit, this being a room devoted to local talent and did not afford sufficient space. The best that could be done in this case was to add blue and green-blue rays to the ordinary artificial light. One-half of the total number of lamps in this room were

coloured. When the walls do not afford sufficient space for proper hanging, freedom from annoying reflection can be obtained by hanging the pictures sufficiently low, as shown in the poster room illustrated in Fig. 7.

General lighting from skylights, windows, and artificial sources suspended from the ceiling in an unprotected manner are nearly always visible by reflection from the glass coverings of the pictures. For this reason these methods do not represent the best principles in lighting, even aside from their inadequacy in properly lighting each painting. Considering the tremendous value of paintings it seems feasible to light them properly by artificial light with the expectation of always viewing them under the same lighting. This obviates much difficulty in providing daylight illumination, which can rarely be thoroughly satisfactory.

Light is the first and last requisite in art. First because the subject owes its existence to light. The painting becomes largely an expression of light. Light is the final requisite because the appearance of the painting is at the mercy of the lighting. The artist is therefore a link between two lightings—a mediary who gives to a mood or appearance of light permanent expression. It is the function of the lighting artist to aid the painter in realising his aim. Science does not pretend to paint pictures, but it can justly claim a place of high importance in properly illuminating them.

REVIEWS OF BOOKS.

Die Beleuchtung von Eisenbahn-Personenwagen. By Dr. Max Büttner. (*Julius Springer, Berlin*, 1912; 235 *pages*, 108 *illustrations.*)

HERE we have another example of a book devoted to a specialised section of illuminating engineering. The author, however, deals exclusively with generating problems and not with the distribution of the light. The first part of the book deals with lighting by candles, oil, petroleum, &c. Subsequently some account is given of the use of various kinds of gas and acetylene, reference being made to the experiences of railway companies using these systems.

By far the larger part of the book is devoted to electric lighting. We have first systems involving the use of accumulators pure and simple, and second, a considerable variety of systems using dynamos in conjunction with accumulators. All these the author deals with in detail, and he adds particulars of the various accessories used in electric train lighting.

THE book is concluded by an analysis of the advantages and drawbacks of the various systems, including a comparison of costs. This is shown to depend very greatly on the number of hours during which artificial light is in use *per diem*, and the author comments on the number of other local circumstances that affect the cost and make general comparisons difficult. We may add that another factor is the way the light is distributed in the carriage, and we hope the author will follow up this volume by a supplementary one dealing with train-lighting from this standpoint.

Report on Fencing and Safety Precautions for Transmission Machinery. By W. Sydney Smith. (*Wyman and Sons, or T. Fisher Unwin, London.*)

The report contains an analysis of the nature of accidents, and is illustrated by a complete series of sketches of 62 designs, classed respectively as satisfactory or defective.

School Planning. By Phillip A. Robson. (*Nicholson, Smith, Amen Corner, London, E.C.* 15*s. net.* 1911. 54 *pages text;* 54 *illustrations.*)

In view of the recent discussion at meetings of the Illuminating Engineering Society on the subject of School Planning, Mr. Robson's book should be of no little interest. The book opens with a lecture on the Hygienic Planning of Schools, reprinted, with sundry additions, from the Journal of the Royal Institute of Public Heath. To this have been added chapters on other modern topics.

The author gives a brief history of buildings devoted to education, which leads us to see the very complex considerations that often decide the site of a school. Of considerable interest to our readers is a series of seventeen practical recommendations on the lighting of classrooms by natural and artificial means. We note that the author allows 50 C.P. per square of 100 ft. of floor area—a figure which he remarks is double that usually considered sufficient. At the present time it is more customary to specify the necessary illumination in foot-candles. Turning to natural lighting, he makes some other suggestions, among others that the designer should aim at getting one-thousandth of the total outside illumination, giving, on an average, one foot-candle the room.

Another very serviceable item is a table summarising data from the building regulations of the Board of Education for elementary, higher elementary, and secondary schools. The special requirements of the two latter classes of schools are not always sufficiently borne in mind, but we note that the author devotes to them a special chapter. He gives some useful hints on grounds for games of various kinds, specifying the area required for lawn tennis, hockey, basket ball, &c. Attention is also given to gymnasia.

The book continues with some notes on the Report of the Departmental Committee on the cost of elementary school buildings. Finally, there is a very complete series of photographs and plans of various schools all over the country. These are executed on art paper and bound by themselves at the end of the volume, occupying exactly the same space as the text (which, we are glad to see, is printed on *mat* paper).

The book deserves attention from those interested in school planning.

Die Verwendung der seltenen Erden. C. R. Böhm. (*Veit Comp., Leipzig,* 1913. 5 *Mk.* 50; 107 *pages,* 10 *illustrations.*)

Dr. Bohm's researches on the use of the rare earths in gas lighting have already been published in several works on the subject.

The booklet before us touches somewhat new ground. Seeing that the annual gas production in Berlin alone now exceeds 500 million cubic metres, it can readily be imagined that the application of thoria and ceria in the incandescent mantle alone now forms quite a considerable industry.

But it will perhaps come as a surprise to many to find how many other uses there are for the rare earths. In the form of mesothorium they are employed for the treatment of lupus and other skin diseases: they now play a considerable part in radiobiology, and in the form of cerite and such-like pyrophoric materials they have recently been applied to automatic ignition. This, however, by no means exhausts their applications. Dr. Böhm instances their use in the glass and porcelain industries, for colouring, polishing, and enamelling purposes and as a protection against rust. They are likewise used in the production of special steels.

In the concluding chapter Dr. Böhm traces the history of the rare earths from the early efforts to make use of these substances up to the recent discoveries in the fields of molecular physics and radioactivity.

Licht und Beleuchtung. By Dr. G. Ehrig. (*W. Engelmann, Leipzig,* 1913. 2 *Mk.* 80; 98 *pages,* 100 *illustrations.*)

One more addition to the considerable number of works on illumination recently published in Germany. The author deals in brief with the chief forms of gas and electric lamps, and the text is abundantly illustrated by pictures of typical illustrations, provided by various well-known German firms. These serve their main purpose in illustrating the nature of the system, but it is evident that in some cases photographs were not taken exclusively by the artificial illumination, and that in others the retoucher has been at work. However, from the pictorial standpoint some of them are effective.

The book should be useful to those desiring a rapid popular summary of present-day illumination.

The Electrical Engineer's Diary. (*S. Davis and Co.*, 30-31, *St. Swithin's Lane, London, E.C. Edited by J. H. Johnson, M.I.E.E.* 3*s.* 6*d.* 1914.)

The Electrical Engineer's Diary for 1914 is quite an imposing volume, and contains a vast amount of general information. Besides the usual tables and particulars regarding the weight, resistance, &c., of cables, we notice a special section of the Application of Electricity in Various Industries, such as agriculture, cinematograph halls, laundries, rolling and cotton mills, &c., where the needs of each industry are concisely stated. A particularly useful item is the approximate electrical horse-power required to drive various classes of machines, and such matters as heating, ventilation and refrigerating plant are also dealt with. A convenient index is provided. The tables relating to electrical supply and the lists of streets falling within the scope of the various companies should be serviceable for reference.

The subject of lighting is very fully treated. Here we find the usual data as regards illumination, photometry, spacing rules for reflectors, &c., and we are glad to see that illuminating engineering receives so much attention. (We notice, by the way, that the question of the comparative costs of gas and electricity for street-lighting is dealt with by quoting the figures for Marylebone and Manchester —surely a somewhat partisan method of treating the subject!)

In the diary itself every page has its corresponding sheet of blotting paper, one side of which is devoted to advertisements.

Das Städtische Gasrohrnetz. By Paul Brinkhaus. (*R. Oldenbourg, Munich and Berlin*, 1913. 5 *Mk.*; 134 *pages*, 22 *tables, and* 69 *illustrations.*)

THIS book forms one of the "Technische Handbibliothek" series, and deals in a concise manner with the distribution of gas. The text is illustrated by many formulæ and tables enabling the diameter of pipe, fall of pressure, &c., to be calculated, a special section being given up to high-pressure distance transmission. An interesting table is given specifying the consumption and population in various cities in Germany.

National Gas Congress Papers (1913).

THE complete set of reprints of papers at the National Gas Congress, held at Shepherd's Bush last October, has now been reprinted and issued by the British Commercial Gas Association.

The series reached us too late last month for reference, and we gladly take this opportunity of expressing our appreciation of the gift. The proceedings at each congress are reprinted in a separate booklet, printed alike on mat paper with brown cover. The whole series is assembled in a convenient case. The printing and paper are excellent, and the Editorial Committee may be congratulated on the whole get-up.

These papers should prove a worthy memento of an important event in the history of the gas industry.

International Electrical Congress, San Francisco, 1915.

PARTICULARS reach us of the International Electrical Congress to be held at San Francisco in September, 1915. Special trains will be run, and the tentative programme includes a trip of about 30 days' duration, with stops at Chicago, Colorado Springs, Salt Lake City, San Francisco, Santa Barbara and Los Angeles. The Committee is also considering transportation by way of the Panama Canal. Those interested should write to the Secretary, Mr. P. S. Millar, 80th Street and East End Avenue, New York, U.S.A.

OTHER PUBLICATIONS RECEIVED.*

Elementary Principles of Illumination and Artificial Lighting. By Arthur Blok. (*Scott Greenwood and Son, London.*)

Incandescent Electric Lamps and their Application. By D. H. Ogley. (*Longmans, Green and Co., London.*)

Die Elektrischen Metallfadenlampen. By G. H. Weber. (*Max Jänecke, Leipzig.*)

Transactions of the Institution of Gas Engineers (*London*).

The Channel Tunnel. (Booklet issued by *The Channel Tunnel Co., Ltd.*)

* To some of these we mean to refer in detail shortly.

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

THE January number of *La Science et Art de l'Eclairage* contains several articles of interest. A. FROGET describes the **Equipment of a Photometric Laboratory** in detail. R. HOUDAYER continues his contribution on "**Lighting of the Past.**" The present number contains some quaint sketches illustrating designs and fittings and ancient methods of lighting from Japan. Another article deals with **advertising by means of light.** A description is given of various forms of automatic signs in which playing fountains, moving figures, &c., are imitated, and of the "Tourbillion," *i.e.*, a rotating rod on which a landscape or design can be projected.

A. L. POWELL describes the complete lighting of a small house, pointing out the characteristic problems met with in each variety of room. In the dining-room he employs a somewhat novel device, consisting of a silk-lined dome having within it a tungsten lamp enclosed in a prismatic reflector. This projects the light downwards on to a surface of light silk, giving a very soft and diffused light, the source being completely concealed from the eyes.

Another American item of interest is the "Nodaz" **headlight glare reducer** (*Elec. Rev. and West. Elec.*, February 7th). The device consists in a couple of vanes which can be opened and closed at will by electro-magnetic means so as to cut down the brightness of the beam whenever the traffic conditions demand it.

In the *Electric Review and Western Electrician* for Jan. 17th is an account of the **lighting of a picture gallery** by a combination of mercury vapour and tungsten lamps, the mixed light being thrown upward on the ceiling and the actual sources concealed. It is said that the strong blue element in the light is an advantage.

Among other articles we note a contribution by "S." on the proposed Standard Specification for Street Lighting (*Gas World*, Jan. 7th). The author states the pros and cons of measurements of candle power and horizontal illumination respectively, and expresses himself in favour of the former method. It is interesting to notice that in the United States a joint discussion on street lighting by the American Illuminating Engineering Society and the American Institution of Electrical Engineers has recently taken place.

ELECTRIC LIGHTING.

Once more the chief item of interest is **the half-watt lamp.** A technical article on the subject appeared in the *Zeitschrift für Beleuchtungswesen* for Jan. 20th. The author gives the polar curve of the new lamps and describes some experiments on their radiation, from which he draws some conclusions as to the probable temperature of incandescence. In the British technical papers there has been some controversy as to how the new lamps should be rated. Experience points to the mean hemispherical C.P. as the most useful factor.

BUJES (*E. T. Z.*, Jan. 15th) contributes an article on the **Moore Light.** He points out that each portion of the tube radiates light and that we have thus a form of "volume radiation" and not "surface radiation." For this reason the ordinary method of designating C.P. fails in the case of the Moore Light. The only proper method of comparison with other illuminants is on the basis of the illumination provided, by a given expenditure of energy, over a certain floor area.

J. SAHULKA (*Elec. u. Masch.*, Jan. 4th) deals with the instantaneous candle-power of alternating current arc lamps. He compares the curves with those of the tungsten lamps, determining the so-called "Hysteresis loop" in each case.

J. T. H. DEMPSTER describes a form of **miniature electric night light** (*G.E.C. Rev.*, Jan.). With the advent of high efficiency low voltage metal lamps and the use of a small transformer the problem becomes quite feasible. The

transformer is tucked away in an ordinary holder. The lamp can be inserted in a socket by the bedside, and gives a feeble glimmer throughout the night with a very small consumption.

GAS, OIL, AND ACETYLENE LIGHTING.

There have not been many articles in this section dealing with illumination. Chief interest centres in the contribution by F. POHL (*J. f. G.*, Jan. 3rd) on the **lighting of the classrooms in the Vienna State Schools** by means of gas. The author gives plans of the rooms, showing the arrangement of the lights and the method of obscuring the lower portion of the globe so as to screen it from the eyes of the scholar. He also tabulates the illumination and gas consumption in each case. The illumination varies from 2–7 f.c., the minimum, therefore, being closely in accordance with that recorded in this country.

The *American Gas Light Journal* (Jan. 12th) has an article on the **Lighting Fixture Manufacture To-day** in which the author points out the importance of fixture and design to the gas industry. The article contains illustrations of a number of modern American designs; there seem to be quite a number of decorative gas fixtures making their appearance in the United States.

The article by F. AHRENS (*Z. f. B.*, Jan. 10th, 20th) on the use of **Acetylene in connection with lights of navigation,** beacons, lighthouses, &c., is also of considerable interest. The author describes the various types of lamps in some detail, making special reference to the use of dissolved acetylene and automatic flashing light contrivances.

It will be recalled that the same author recently dealt with the application of incandescent oil lights in the same field.

F. A. EBERT (*L. u. L.*, Jan. 15th) describes some new systems of lighting based on the use of oil, petrol, or gas, &c., and in a recent number of the *Rev. des Eclairages* there is an article summarising progress in France in the lighting of small towns by acetylene.

LIST OF REFERENCES:—

Illumination and Photometry.

Curtis, A. D. Indirect Lighting in the Home (*Elec. World*, Jan. 17th).
Editorial. The Lighting of Pictures (*Elec. Rev. and Western Electrician*, Jan. 17th).
Froget, A. Un Laboratoire Photometrique Pratique (*Science et Art de l'Eclairage*, Jan.).
Houdayer, R. L'Eclairage à travers les Siècles (*Science et Art de l'Eclairage*, Jan.).
Ives, H. E. Lamps and Lighting in the Future (*Elec. World*, Jan. 24th).
Powell, A. L. Methods of Lighting a Small Residence (*Elec. World*, Jan. 24th).
Schanz, F. Uber die Veränderungen und Schädigungen des Auges durch die nicht direkt sichtbaren Lichtstrahlen (*Z. f. B.*, Jan. 10th).
"S." The proposed Standard Specification for Street Lighting (*G. W.*, Jan. 17th).
Show Window Lighting and Display Lighting (*Elec. Rev. and West. Electrician*, Feb. 7th).
"Nodaz"—A headlight Glare Reducer (*Elec. Rev. and Western Electrician*, Feb. 7th).
Das Beleuchtungswesen im Jahre 1913 (*Z. f. B.*, Jan. 10th; *L. u. L.*, Jan. 15th).
La Publicité Lumineuse (*Science et Art de l'Eclairage*, Jan.).
Street Lighting (Joint discussion of the Am. Illuminating Engineering Society and the Am. Institute of Elec. Engineers, *Elec. Rev. and West. Electrician*, Dec. 27th, 1913).

Electric Lighting.

Bujes, J. Beitrag zur Kentniss des Moorelichtes (*E. T. Z.*, Jan. 15th).
Dempster, J. T. H. A Miniature Electric Night Lamp (*G. E. C. Review*, Jan.).
Editorial. Electric Lighting during 1913 (*Electrician*, Jan. 16th).
The Rating of Electric Lamps (*Electrician*, Feb. 13th).
The Half-Watt Lamp and the Mantle Burner (*G. W.*, Jan. 17th)
The Half-Watt Lamp (*Elec. Rev.*, Feb. 6th).
Studies of Vapour Lamps (*Elec. World*, Feb. 7th).
The Ten-Watt Lamp (*Elec. Rev. and West. Electrician*, Jan. 31st).
Ponti, G. Il sistema di illuminazione con lampade ad incandescenza in serie e trasformatori a corrente costante (*Atti della Assoc. E. Elettr. Ital.*, Dec. 15th, 1913).

Sahulka, J. Momentane Lichtstärke von Wechselstrom Bogenlampen (*Elek. u. Masch.*, Jan. 4th).
Watts, J. Manufacture of Metal Filament Lamps (*Electricity*, Jan. 9th).
A long burning enclosed Flame Arc Lamp (*Elec. World*, Dec. 27th, 1913).
Untersuchungen an der Halbwattlampe (*Z. f. B.*, Jan. 20th).
Lampe à vapeur de mercure Billon-Daguerre (*Rev. Electrique*, Dec. 19th).
Nouveau Procédé pour faire le vide dans les lampes à incandescence et dans l'autres recipients en verre (*l'Electricien*, Jan. 3rd).
The Half-Watt Lamp (*Corresp. Elec. Rev.*, Feb. 6th).
Village Lighting (*Elec. Rev.*, Feb. 6th).

Gas, Oil, Acetylene Lighting, &c.

Ahrens, F. Das Azetylen in der Leuchtfeuerindustrie (*Z. f. B.*, Jan. 10th, 20th).
Ebert, F. A. Neue Beleuchtungsmöglichkeiten (*L. u. L.*, Jan. 15th).
Pohl, F. Uber Lehrzimmerbeleuchtung mittels Gas in der Wiener städtischen Schulen (*J. f. G.*, Jan. 3rd; *G. W.*, Feb. 7th).
Progrès dans l'Eclairage des Villes par Acétylène (*Rev. des Eclairages*, Dec. 31st).
Lighting Fixture Manufacture to-day (*Am. Gaslight Jour.*, Jan. 12th).

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
J. f. G.—*Journal für Gasbeleuchtung.*
L. u. L.—*Licht und Lampe.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

SHOP LIGHTING by

HALF WATT OSRAMS.

The accompanying illustration, reproduced from a photograph taken entirely by the light of the lamps, shows the excellent distribution of light obtained from Osram Half-watt lamps at Messrs. Harrod's premises, Brompton Road, S.W.

The lamps are fitted in "Equiluxo" glassware spheres.

Full particulars and prices post free on request.

THE
General Electric Co.,
Ltd,
Head Office:
67, Queen Victoria Street,
London, E.C.

VIEW OF ONE OF THE COUNTERS AT MESSRS. HARRODS.

TRADE TOPICS AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

BENJAMIN LIGHT SPECIALITIES.

We have just received the new issue of Benjamin Lighting Specialities (List No. 53) which has a number of original and distinctive features. The cover is buff, with the title in blue, and the interior is printed on cream mat art paper, so that there is no "shiny reflection" such as is likely to trouble the eyes. As is well known the reproduction of half-tone blocks with paper of this kind needs some care, but in this case the result has been quite satisfactory. A feature in the arrangement of the illustrations is the way in which a general view of each fitting, and the corresponding data, are reproduced on the right-hand page; while the left-hand page is given up to photos (taken by artificial light) of installations in which these units are employed. For example, the picture of the semi-indirect cluster fitting faces a view of an insurance office illuminated on this system, the data on steel reflectors face a view of a factory with local lighting by these units, &c.

The list contains a very varied selection of lighting units of all kinds as well as such specialities as shockproof hand lamps, wireless adapters, "Benco" lampholders, &c. Another special feature is the introductory section on Industrial Lighting Data in which a considerable amount of useful information is given.

In several respects the list is an interesting departure from the ordinary tradition in catalogues of lighting specialities.

We are also asked to mention that after March 9th **The Benjamin Electric Co.** will transact all business from their offices and showrooms at 1A, Rosebery Avenue, and 17–25, Laystall Street, E.C. (Holborn 1830).

PHOTOMETER POLAR-CURVE PAPER.

Messrs. Franz Schmidt and Haensch (Berlin) send us a sample of a new form of paper for plotting polar curves, which is claimed to diminish considerably the labour of calculating the mean spherical candle-power. Superimposed over the ordinary polar co-ordinates are twenty dotted lines. These are selected at such intervals that the mean of the intensities in these directions is equal to the mean spherical candle-power. All that is necessary, therefore, is to read off and add up the values along each of these dotted ordinates and to divide the result by 20.

ARTISTIC ELECTRIC LIGHT FITTINGS (Edison and Swan).

The latest catalogue of Ediswan fittings contains an excellent selection of English and French types, some of the sections, such as the portable lamps, hall and vestibule lanterns, and electroliers, being very fully treated. At the end of the catalogue is a series of semi-indirect fittings, which forms quite a special feature. Many of these are reproduced with a black background—a style which has some distinct advantages over the ordinary method.

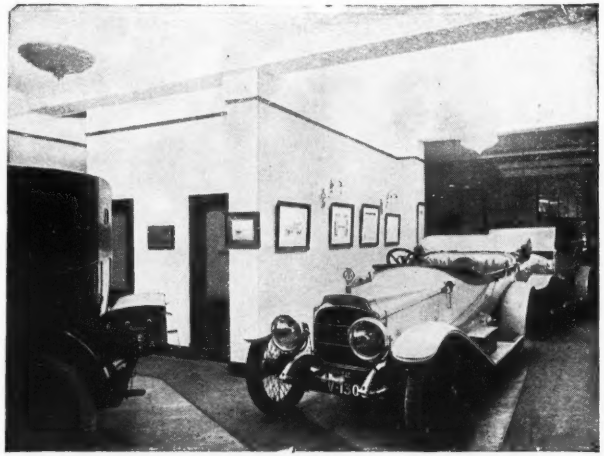
Most of these novelties can be seen at the company's new showrooms, in Queen Victoria Street.

ADDITIONS TO G.E.C. BOUND CATALOGUE.

The **G.E.C.,** recognising the desirability of keeping their well-known bound catalogues thoroughly up to date, are making a practice of issuing quarterly "progress sheets." This will enable owners of the complete index either to add to or correct the existing volumes, and we note that each of these quarterly supplementary sections contains a complete cross index.

THE "BARGAIN BASEMENT" AT SELFRIDGE'S
(Oxford Street).

Mazda half-watt lamps in Alba Spheres. By installing these lamps an increase in illumination from 2·5 to 7·5 ft.-candles was secured, and a saving of 36% in current consumption effected. Further particulars of these half-watt fittings can be obtained on application to Mazda House (Upper Thames Street, E.C.).



VAUXHALL MOTOR CO.'S SHOWROOM
(Gt. Portland Street).

Mazda "half-watt" lamps in "Eye-rest" bowl-fittings. The general distribution of light and avoidance of sharp shadows is an important factor in a motor-car showroom, and the use of the half-watt lamp is very favourable to indirect lighting.

TWO B.T.H. "HALF-WATT" INSTALLATIONS.

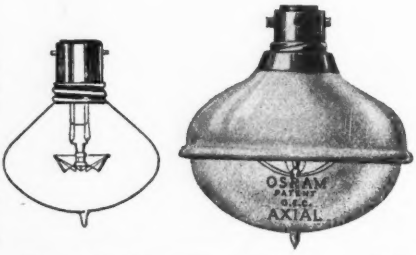
A "HOLOPHANE - HALF-WATT" INSTALLATION.

This picture shows a view of a department in Bentall's Store at Kingston. This Store is being equipped with fifty half-watt lamps in Holophane reflector-hemispheres, and over half of these units are now in actual use. The white light given by these lamps, softened and diffused by the Holophane glassware, is excellently adapted for a store of this kind.

ORAM "AXIAL" AND ROYAL EDISWAN "DOWNLITE" LAMPS.

Here are two new forms of drawn-wire lamps, brought out respectively by the **G.E.C.** and the **Edison and Swan United Electric Light Co.**

The illustration shows the Axial lamp the filament of which is arranged conically to give a strong downward light—very different from that yielded by the ordinary vertical metallic filament, and specially suitable for the lighting of billiard tables, compositors' desks, special tools, &c.



Singularly the Royal Ediswan "Downlite" lamp utilises drawn-wire horizontal filaments, throwing most of the light downwards.

Both lamps can be provided with very compact opal reflectors.

INDEX, March, 1914.

PAGE

Annual Dinner of the Illuminating Engineering Society
[Speakers:—Sir Boverton Redwood—Sir William Bennett—Mr. L. Gaster—Sir William Crookes—Sir Henry Trueman Wood—Mr. A. W. S. Cross, F.R.I.B.A.] 139

Correspondence (The Rating of Illuminants) 138

Editorial .. .. L. GASTER 105

Illuminating Engineering, a Year's Progress in (*concluded*) 109

Illuminating Engineering Society—
(Founded in London, 1909.)

Account of Meeting on Feb. 17th 147
Annual Dinner 139
New Members 147
Next Meeting 146

London, Lighting of .. .. L. GASTER 117

Picture Galleries and Art Studios, Lighting of (*to be continued*)
[Prof. S. P. Thompson—Mr. F. W. Goodenough—Mr. A. P. Trotter—Mr. David Murray, R.A.—Sir Joseph Pennell] 148

Picture Lighting, effect of colour and direction of light, M. Luckiesh 157

Reviews of Books 162

Review of the Technical Press 165

Statistics on the Lighting Art .. .. .. P. S. Millar 114

Trade Topics 168

AN INGENIOUS SIEMENS ADVERTISING NOVELTY.

Messrs. Siemens Bros., Dynamo Work Co. (Tyssen Street, Dalston), send us a most ingenious advertising device—a knife engraved with the word "Wotan," and which, to the uninitiated, obstinately refuses to open.

Closer investigation (aided by instructions from Messrs. Siemens) shows that this behaviour is due to a small rolling shot fitting into a slot at the base of the blade. When the knife is held with the point of the blade upwards, a slight pressure on the top of the blade causes it to spring open. Conversely, by pointing the blade downwards the shot changes position and a slight pressure closes the knife.

"MAZDA HOUSE NEWS" FOR JANUARY.

This issue contains photographs of many widely different installations. Among the most interesting are those of a gymnasium, a swimming bath, and a large riding school, the girder-roof of which is studded with mazda lamps in special lanterns.

CATALOGUES RECEIVED, &c.

Evershed and Vignoles, Recording Ammeters, Voltmeters, and Watt-ameters. Foster practical Pyrometers.

Dick, Kerr & Co. Ltd., "Britannia" lamps.

Veritys' Ltd., prices of Monarc and Aston enclosed arc lamps, and Aston "Radiant Lanterns" for shops, offices, stations, and street lighting.

Herbert Monarcs and Co., Ltd., Overhead travelling cranes.

Lead, Ltd. (Westminster), Particulars of a new process for coating metal and non-metallic substances with lead.

Edison and Swan, Ponder's End Works, An interesting and well-illustrated account of this company's new works at Ponder's End, reprinted from the *Electrician* for January 9th, 1914.

Sun Electrical Co., Ltd., Lists of small motors, miniature candle, tubular and other lamps. A special feature is the "Kingolite" candle.

THE IMPORTANCE OF OPERATING LAMPS AT THE PROPER EFFICIENCY.

The following is an interesting note received from the British Thomson Houston Co. on the above subject :—

The question of the actual efficiency at which an incandescent lamp operates is one which up to now has received altogether too little attention. Simply because an incandescent lamp was rated at a certain efficiency by the manufacturer it was assumed that this rating would hold, regardless of the conditions under which the lamp operated. The point was overlooked that the manufacturer's rated efficiency, candle-power, watts, life, &c., only hold when the lamp is operated at rated voltage.

It is important that the average voltage at the holder should be the same as the voltage marked on the lamp. Speaking generally, for every one per cent. increase of impressed voltage on a given lamp the wattage will increase 1·6 per cent.

Let us consider the advantage to the central station of operating a 60-watt Mazda lamp at high efficiency instead of at low efficiency. In 500 hours burning a 60-watt Mazda lamp consumes 30 kilowatt-hours. If this lamp were operated at 96 volts instead of 100 volts there would be a loss to the central station of 1·8 kilowatt-hours. With 10,000 lamps in service, and assuming 500 hours to be the average annual burning period, and the charge per kilowatt hour to be 4d., this would represent an annual loss in revenue of £300.

In the majority of cases the purchase of lamps of correct voltage would have prevented this loss in revenue without any increased cost. That is, it would represent 10 per cent. dividend on a £3,000 investment. Provided the low efficiency operation was due to loss in transmission, the lighting company would have been justified in investing £3,000 to obtain this additional revenue. Improving voltage conditions in this manner would not only increase the consumption of lamps, but would have just as important an effect on other apparatus, such as flat-irons, toasters, fans, &c.

Investigations show that many lamps are operated at from 3 to 4 volts below their rated voltage.

Some of the advantages of burning lamps at their rated voltage are :—

1. 10 to 15 per cent. more light, hence more satisfactory service to the consumer.

2. A better quality of light, due to operating the lamps at a higher temperature.

3. It puts electric light in a position to compete more favourably with other types of illuminants.

4. It relieves the central station of service complaints, most of which are due to the inefficient operation of lamps.

5. It permits the use of lower voltage lamps where overload of the distribution system has caused a drop in voltage, often obviating the necessity of increasing the capacity of the distributors.

The efficient operation of lamps secures the maximum revenue for the central station, the maximum light, economy, and satisfaction for the consumer. To ensure efficient operation, the central station *must keep its voltage constant*, and the consumer must use lamps *marked with the actual voltage at the lampholder.*

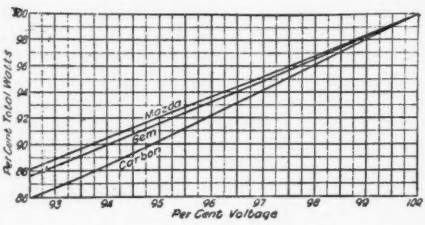


Diagram showing the per cent. decrease in watts consumption when Mazda, Gem, and Carbon lamps are under-run.

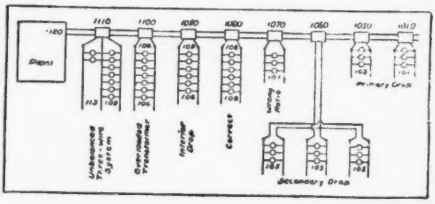


Diagram indicating the usual reasons for low supply pressures.

Mr. G. Middlecoat, of the Southampton Corporation Electricity Works, is resigning his position with the corporation and joining the staff of the Edison and Swan United Electric Lighting Co., Ltd.

4

The
ILLUMINATING
ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by
LEON · GASTER

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EDITORIAL.

Illumination Estimates and Performance in Practice.

During the last few years a great change has taken place in the design of lighting installations. People are no longer satisfied with vague estimates as to the performances of the lamps installed. It is recognised that the amount of illumination required for various purposes should be definitely stated in terms of " foot-candles," and that installations should be designed to give, within reasonable limits, the illumination required for the purpose.

It is therefore of interest to inquire whether we are yet in a position to determine beforehand, and with sufficient precision, what the illumination is going to be, assuming that particulars are known of the lamps and shades employed, their spacing and height, &c. This problem was taken up by Mr. Clinton in his paper before the last meeting of the Illuminating Engineering Society. Mr. Clinton has taken a typical series of installations: starting simply from the polar curves provided and a knowledge of the positions of the lights in the interior, he has worked out what the illumination should actually be, and compared this with the value actually found in practice.

It will be observed that these calculations refer to actual installations.

In these cases the agreement is very good, the calculated values in general falling somewhat below those actually found, owing to the effect of reflection from walls and ceilings. This is an indication of what might be expected in practice. The usual method in predetermining illumination is to regard this additional light as a margin, thus ensuring that the illumination provided may be more but will not be less than that required.

The more intricate and original the lighting scheme adopted the more necessary such predeterminations become. It is natural that engineers who are accustomed to deal exclusively with installations of a certain kind should rely on their experience, or depend to some extent on semi-empirical rules which they have found to answer well in this class of work. But in the higher branches of illuminating engineering, where the skill of the engineer and the creative faculty of the architect are blended, and where new and original situations may arise, the degree of success may depend very largely on the ability of the engineer to undertake calculations of a highly intricate kind.

Mr. Clinton's paper, therefore, is naturally one of great interest to the lighting expert. But we venture to predict that the results he has arrived at will be followed with close attention by many outside the Society. The tendency in the lighting industry at the present time is to discard the old "rule of thumb" methods and to place matters on a more scientific basis. It is becoming quite usual even for non-technical people to have a very fair idea what is meant by a foot-candle. Committees who study these problems find it essential—in fact, the very first step in their proceedings—to decide on the exact numerical value of the illumination required. It is evident, therefore, that in the near future it will be essential for the success of any company interested in lighting to be in a position to make calculations of this kind, or to supply data which will enable others to make them.

Scientific Training and Modern Business.

At the Annual Dinner of the General Electric Co., which took place on Saturday, March 14th, the Chairman (Mr. H. Hirst) drew a fascinating picture of the progress to be expected of the electrical industry within the next few years.

Mr. M. J. Railing, who responded to the toast of the Company, referred to the value of scientific training in modern business. He pointed out that in the present day this country, instead of acquiring new territory by force of arms, used the more peaceful methods of trade and industry, continually introducing better and more scientific industrial methods.

Mr. Railing added that in the future closer co-operation between technical institutions and the industry should be established; moreover, students should gain an all-round knowledge by spending part of their time in the colleges in this country, and also some time in the corresponding institutions in the Colonies and in other countries. Thus, when they go out to do their work in any part of the Empire or in foreign lands they will be familiar with the local conditions and educated to supply the needs of the country to which they go. There should also be some concerted scheme of education in institutions within the Empire (and, if possible, all over the world), so that the courses of instruction may follow similar broad lines, and a student can readily pass from one to another.

We are delighted to note this enlightened appreciation of the need for science in industry. We are equally glad to see in the addresses of Mr. Hirst and Mr. Railing a touch of that idealism which forms the inspiration of modern commerce. The day is past when a great engineering firm can secure enduring success by working on narrow and short-sighted lines. A flourishing business, in order to justify its existence, must give of its best, must take wide views of its obligations, and must be prepared sometimes to do work by which others will also profit. As an instance we should like to mention the laboratory established by the National Electric Lamp Association in the United States, where many researches, having a value beyond the immediate commercial interests of the Association, have been carried out and published, with the intention of benefiting the world at large.

Employer and employee, as Mr. Hirst rightly said, must trust each other and must feel that both are doing their share towards building up the business.

Whether or no this spirit exists depends to a great extent on the leaders of the business. If their views are petty and their standards low there will never be a true spirit of co-operation in the rank and file.

If an example in this respect is set by the large companies we may be sure that the smaller ones, if they wish to exist at all, must follow.

Testing the Colour-values of Illuminants.

In our last issue we referred incidentally to the question of colour-discrimination by artificial light, in connection with the lighting of picture galleries. In the conclusion of the discussion of this subject, which appears in the present number, this matter is frequently referred to.

We also notice, in a recent number of the *Elektrotechnische Zeitschrift*, contributions by Dr. L. Bloch and Herr Jasse on this problem. Dr. Bloch,

like Voege and others, uses an ordinary photometer, substituting red, green, and blue glasses for the prism; each of these screens being in turn placed in front of the eyepiece of the photometer. Subsequently he presents an ingenious form of diagram in which the position of an illuminant as regards resemblance to daylight is determined by plotting the ratios Red/Green as ordinates and the corresponding Blue/Green values as abscissæ. The position of diffused daylight is fixed by the intersection of a vertical and horizontal line for which these ratios are assigned the value of 100.

It is most interesting to see how certain groups of illuminants approach more or less nearly to daylight. We find that for some of them the Blue/Green ratio is almost correct, but the Red/Green ratio is considerably removed from the daylight value; for others the converse is the case. Only in a few instances are *both* ratios at all near to daylight.

Herr Jasse suggests a modification of Bloch's method, locating the positions of the illuminants within a Maxwell colour-triangle, the vertices of which correspond respectively with pure red, green, and blue. An interesting comment is that similar tests of illuminants in the United States give approximately the same relative positions, but that in all cases the illuminants were found to contain relatively less blue and more green. Possibly this is accounted for by a difference in the colour of normal daylight in the two countries.

Simple methods of testing of this kind are not without value. In the course of a lecture by the writer before the Society of Dyers and Colourists on March 26th it was pointed out that for certain classes of work, where only a limited range of colours had to be tested, a fair approximation to daylight is all that is strictly necessary. No doubt there are many such cases in which an approximate method of testing such as that proposed by Dr. Bloch would answer the purpose.

Another point of great interest to those engaged in colour-testing processes is the description and nomenclature of colours. One of the most complete series of this kind is the "Répertoire de Couleurs," issued by the Société Française des Chrysanthémistes and used by the Royal Horticultural Society in this country. The two volumes contain a remarkably complete series of coloured plates, each colour being reproduced in a definite series of graduated shades, numbered and named in four languages. This forms an international schedule of colours by the aid of which any tint can be referred to by name and identified for purposes of reproduction.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE LIGHTING OF PICTURE GALLERIES AND ART STUDIOS.

(Discussion at a Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W.C., on Tuesday, February 17th, 1914.)

(*Continued from p.* 156 [*March issue*].)

During the meeting MR. F. W. GOODENOUGH was obliged to leave and MR. R. J. WALLIS-JONES took the Chair in his stead.

MR. V. H. MACKINNEY, referring to the criticism of the Tate Gallery, remarked that the impression produced on the eye depended greatly on visual accommodation. During the night one's eyes seemed to be tuned to the light from the tungsten lamps. Consequently a picture illuminated by artificial daylight would not produce the same impression as would the same picture illuminated by natural light in the daytime.

In the lighting of picture galleries he had taken a good deal of interest, and had tried to aim at illuminating a surface reasonably uniformly, or with the illumination designed to diminish in a definite manner according to what the artist would think best for the particular picture. He had developed a special reflector for this purpose and the result was shown in the picture exhibited. This principle could be applied to the Art Gallery at Edinburgh, and could also be adapted with a little alteration to the admirable scheme brought to the notice of the meeting by Mr. Pennell.

There should also be no difficulty in applying the daylight principle to this

Picture of The Madonna and Child lighted by special reflector (seen at top) giving uniform illumination. (Mr. V. H. Mackinney.)

reflector, by inserting in front of these lamps either gelatine screens of the type designed by Dr. Kenneth Mees or special coloured glass as advocated by Mr. Trotter. In connection with the desirability or otherwise of artificial daylight in a gallery, he thought that the lighting of a private portrait gallery was often a somewhat different matter from the illumination of public display of pictures. For example, he had met cases in which the mellow rays of carbon filament lamps had been preferred to the whiter tint from tungsten lamps, on the ground that the massive frames appeared to better advantage. With tungsten lamps the frames lost the "rich gold" appearance and the colour resembled that of brass. He had tried to meet this point by using a golden coated reflector behind the tungsten lamp and thus accentuating the yellow component without losing any material amount of light by absorption.

MR. PERCY BIGLAND, referring to the use of metal reflectors in art galleries, said he had tried a great number of these in his studio, but none had given such good results as a piece of whitened canvas.

MR. MURRAY said he had been struck by the emphasis which had been placed upon the difficulties with green. Painters however, when under the influence of artificial light, found the yellows and the violets more trying than green, particularly such yellows as lemon and pale cadmium, and when getting into the violets again, it was here that colour became a trap to the artist, who found in the morning that they had sometimes gone very far wrong; very seldom did they go wrong in the greens. Reference had been made to the American system of having particular lights for particular pictures, but the thing was absurd. A work of art would prove itself a work of art under all conditions to the discerning, and there was no need for a gallery to keep a limelight man for various pictures.

MR. S. E. THORNTON referred to the individual lighting of pictures by means of reflectors attached to the wall close to the frames, or to the frames themselves. It seemed to him that the best result might be obtained if the position and angle of the reflector could be adjusted by the artist himself. He could then direct the light according to his intention; for instance, if he wished for greater brilliancy in the portion of his picture which contained the highest lights he would direct the maximum light to these parts.

He had often noticed that when the lighting of individual pictures had been put in hand many beautiful points and intentions of the artist hitherto unnoticed had revealed themselves.

MR. W. E. BUSH said Prof. Thompson appeared to group together "cornice lighting" and the ordinary form of indirect lighting from fixtures. As regards picture galleries, it was, in his opinion, important not to confuse the two. With cornice lighting, there was a tendency when looking at the higher pictures for the eye to catch the brightly lighted cornice, with the result that the pupil of the eye would close and the picture would not be seen properly, whereas this was a condition which did not occur with indirect lighting from fixtures in the centre of the room or behind the observer. He had brought with him a lantern slide showing a picture gallery illuminated by the indirect system, in which it would be noticed there was a complete absence of shadow, and no reflection from the glass of the picture because of the diffusion of the light.

Another point in favour of indirect lighting was its greater efficiency over local lighting for each picture. At the same time it was not always possible to use indirect lighting, and then it became essential to adopt something more local. In this connection he would like to take the opportunity of explaining a method of lighting employed in an art exhibit in America, where this matter was gone into very thoroughly by several well-known engineers. Mr. Luckiesh, to whom reference had already been made, played a large part in this installation. A trough was run the whole length of the exhibition, and inside the trough were placed 1,000 outlets, 1 ft. apart. The trough was not a reflector, but was painted black and the outlets consisted of a small half-reflector on a universal socket which could be rotated. Having so many outlets, it was

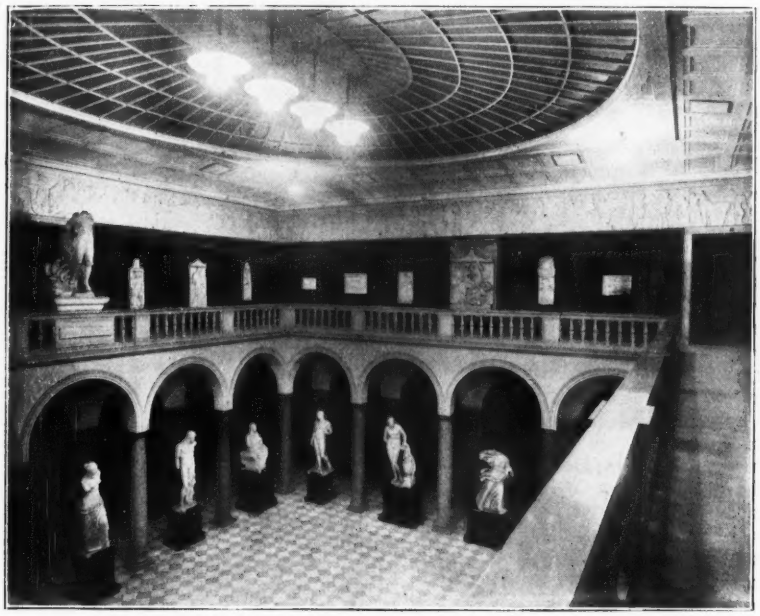


FIG. 1.—Showing semi-indirect arc lamps arranged to reproduce skylight lighting.
(Photo taken entirely by artificial light.)

FIG. 2.—Showing good relief of statuary under semi-indirect arc lighting.

possible to throw the light exactly where it was wanted, and colour was introduced as was found necessary. In this way, by treating each picture individually, very fine results were obtained.

MR. JUSTUS ECK, speaking with regard to sculpture, which had been mentioned by Prof. Thompson, said that during his travels abroad, he had visited the Gardens at Ballarat, and seen four beautiful statues placed in a glass house. These statues for many years had failed to receive any appreciation, but some ingenious person found that although there was plenty of light, it was coming from too many different directions. The light was then partially screened off, with the effect that the beauty of the statuary was so emphasised, particularly of the statue of Suzanna and the Elders, that the Guardians of the building had engaged watchmen to protect the statuary, which was now enormously increased in estimated value, and believed to be quite unique in quality and appearance.

MR. THOMAS E. RITCHIE said that Prof. Thompson had laid great, but not too great, emphasis on the importance of the preponderating light coming from overhead and had shown drawings of an interesting example of the skylight lighting of one of the new galleries.

He had also very rightly emphasised the importance of a great deal of daylight but had not he thought touched upon the important question of the diffusion of the light. There was no doubt that much of the value of the large amount of daylight demanded by Prof. Thomson lay in its great diffusion, as it was well known that however unidirectional daylight lighting might be its diffusion was invariably considerably greater than that obtained from many forms of artificial lighting.

It was not only necessary to have the artificial lighting similar to daylight as regards its main direction but also as far as possible as regards its diffusion, and, for the lighting of Art Galleries more especially, of course, as regards its colour.

An interesting example in which all these points had received attention and which had been proved most successful in practice was shown by Figure 1 reproduced from an untouched artificial light photograph of one of the rooms in the Aberdeen Art Gallery.

The mention of colour brought him to the points raised by Mr. Murray, with whom he was in complete agreement. In all the experiments with which he had been associated, and they had been many, because apart from his own humble efforts he had had the privilege of assisting in the development of a colour-matching lamp of the type which Prof. Thomson had touched upon, and which has also been largely used by the Bradford dyers. He had also assisted in tests carried out in connection with three-colour printing on behalf of the silk industry, in the matching of fats and oils, in the grading of seeds, and in quite a number of more or less extraordinary processes in which differentiation of minute shades of colour paid a very important part—in all of these the question of the yellows had been judged by those concerned to be amongst the supreme difficulties.

He was glad of the confirmation of so eminent a colourist as Mr. Murray upon this point, because it was just in the matter of the correct rendering of the yellows and purples that so many of the more or less superficial screening devices were so completely at fault. It was very easy to get a moderately correct approximation, but very difficult indeed to get, in this way, results sufficiently accurate for those people whose demands it was essential should be met in order to enable them to pursue their daily occupations—let alone to meet the requirements of artists and those concerned with the lighting of art galleries. Another point which had not been sufficiently emphasised was that the use of any colour screen or filter brought about a very considerable falling off in the efficiency of the light source because even the best of these screening devices absorbed anything from 50 to 80 per cent. of the light. This was a very important factor indeed when illuminating a large area such as that of an art gallery or an art school, as the great increase in the cost of the lighting introduced by their use was one which those who were responsible for the

FIG. 3.—Showing light and shade in low-relief objects lighted by semi-indirect arc lamps.

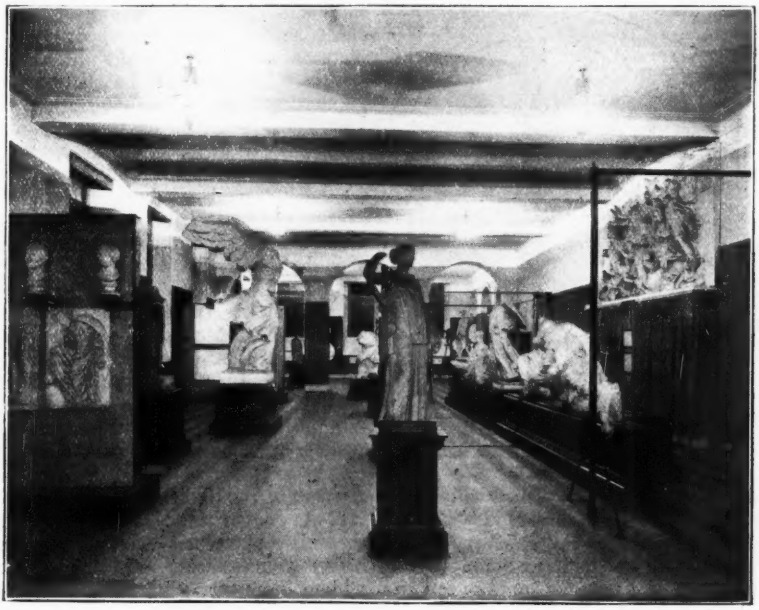


FIG. 4.—Showing statuary and low-relief objects lighted by semi-indirect arc lamps.

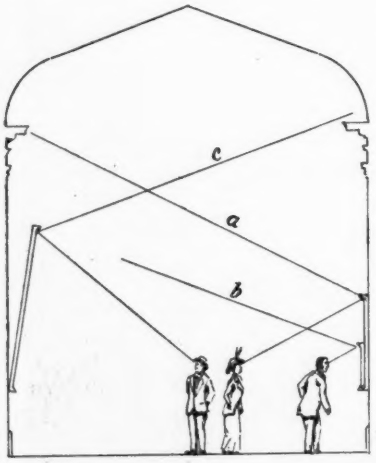
maintenance of such establishments could not possibly afford to lose sight of.

One of the previous speakers had touched upon the question of statuary, and Prof. Thompson had, he thought, suggested that certain forms of indirect lighting might give results of too flat character. Figs. 1–4 would therefore be of interest as showing the excellent results obtained by the use of suitable light sources of this character.

JOHN DARCH (*communicated*): I should like to contribute to this interesting debate a few conclusions that appear to me to govern the lighting of picture galleries, and to include a few comments on the remarks of some of the speakers.

1. A well-lit gallery needs much more light than is generally provided. The whole of the roof should be of glass. But—

2. A low light must be avoided. The limit is shown in the accompanying sketch, where the ray of incidence (*a*) that would reflect into the eyes of the observer, when at a reasonable distance from the picture, just avoids the average and



smaller-sized pictures. This will also cover the necessary closer viewing of small pictures (see ray *b*). Very large pictures should not be hung amongst the smaller, but, if it must be so, they can be tilted in order to lower the angle of reflection (see ray *c*).

3. An important element in the successful lighting of a picture gallery is that of contrast and emphasis — of bringing forward the picture by illumination and of retiring everything else. Mr. Pennell's suggestion of putting the spectators in comparative darkness by (as I understand it) a horizontal screen in the centre of the room is, to borrow Mr. Pennell's own expression, a "trick"; and a very good one too, as far as it goes, but it does not go far enough, for the floor below and the walls around the pictures are, in Mr. Pennell's scheme, still illumined equally with the pictures and therefore detract from them. The idea has, however, been perfectly carried out in the smaller exhibitions of single great pictures, where the spectators are ushered into a darkened room and the well-illumined picture occupies a sort of theatrical stage. But the habitués of ordinary picture shows like to see one another; there is a "society" element that, I am afraid, cannot be ignored. Now, both objects can be easily met, and more perfectly, by the simple expedient of having a moderately dark and dull floor and walls to the gallery; for no amount of light on such surfaces could have a detractive effect, as it would be absorbed, while the pictures would stand out in all their beauty. This would be better than blanketing the visitors under a screen.

4. The treatment of the walls is of utmost importance. I cannot agree that they should be white or light-coloured, for they would produce reflections in every picture. They should not be glossy. Primary and secondary colourings should be strictly avoided. The floor should be rather dark and the walls, up to some distance above the pictures, of some dark and not too definite colour. Even gold bronze is to be avoided: the Turner Room in the National Gallery is so finished, and the pictures thereon recede into insignificance. A wide frieze of a clean white should occupy the upper part of the walls, and the woodwork and surfaces of ceiling be white.

5. As to artificial lighting. Where there is an extensive ceiling nothing is better than indirect lighting; but this seldom happens, and it is useless to attempt it with reflectors. If the pictures are set for a certain angle of daylight the

artificial lighting should be from the same angle, though not necessarily from the same distance as the windows. The lighting should be direct, but the lights should be hidden—every one—and placed so as not to reflect from the pictures. The greater the distance the source of light from the pictures, the more even will be the lighting.

6. The charm of artificially illuminated individual pictures is just that of contrast and emphasis before referred to, and this mode of lighting is especially useful in bringing out the detail of valuable old-time darkened paintings. The ordinary picture reflectors are far from satisfactory; those only are of service that will give reasonably even lighting, sufficient lighting, and that can be so placed as to avoid their own reflection in the picture.

7. The colour of artificial light is, obviously, of great importance in a picture gallery, for colour in a picture is not inherent, but is just what the light, in which we see it, makes it. The ordinary light of commerce biases every colour, except red, to an extent that is incredible until demonstrated. If, therefore, a picture is painted in daylight it can only be properly appreciated in daylight, or, short of that, the nearest possible approach to daylight. Unfortunately, most of our experiments in artificial daylight have been with incandescent lamps, the cost of the energy to which is spent in such large percentage in the production of the lower frequency waves—the ruddier light—hence, when these are cut off by daylight screens, scarcely 25 per cent. of light remains, and the necessary increase of initial light involves a prohibitive expenditure. The new high-power half-watt lamps should be of service for this purpose. But why not employ the white arc lamp, so much more liberal in the higher frequency waves and so much more economical for artificial daylight? Mr. Pennell was a bit "rough" on Prof. Thompson in doubting his artist friend's experience with an arc lamp, but perhaps Mr. Pennell has had no experience with white arc lamps, or he would have known that it would be easy not to notice the decline of daylight under them.

8. As to studios, Mr. Pennell stated that there was not the least relation between the lighting of a studio and that of a picture gallery. Surely he is mistaken. Is not the character of the light, abnormal or otherwise, in which a picture is painted just the very light in which to exhibit it? An artist can hardly be expected to be successful with a picture painted under different conditions of light from that in which it is to be seen. It follows, therefore, that the nearer the lighting of studios and galleries approximate the better for the pictures.

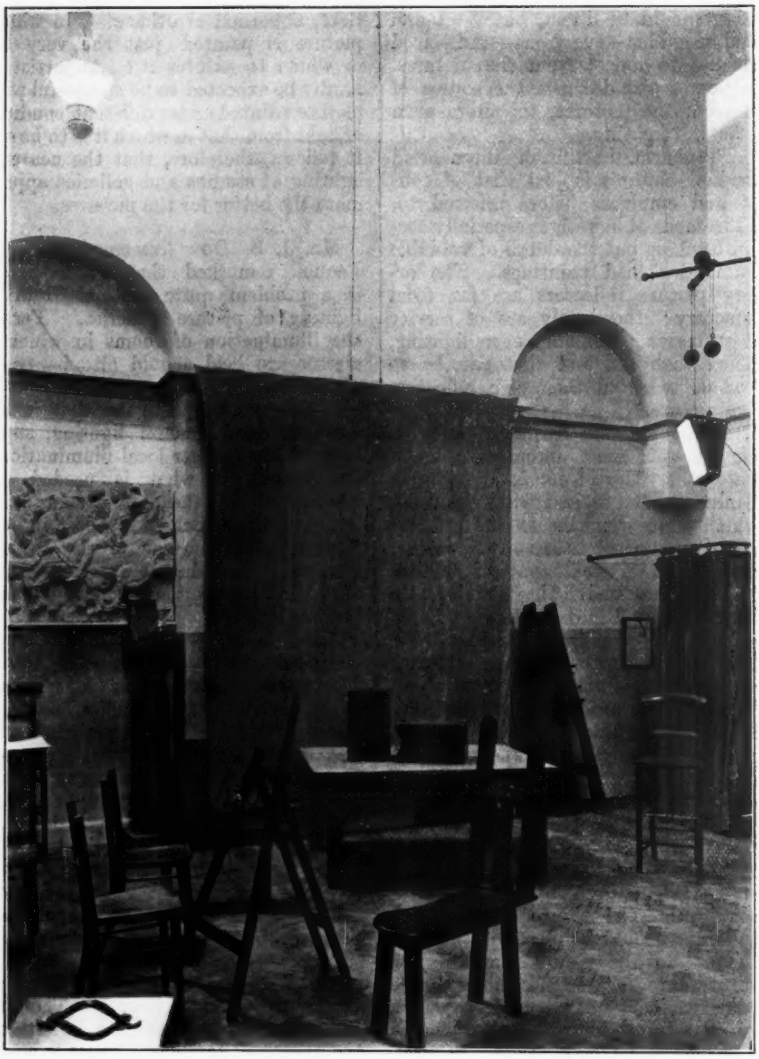
MR. J. S. DOW (*communicated*): Mr. Pennell remarked that studio-lighting is a problem quite distinct from the lighting of picture galleries. Possibly the illumination of rooms in which art classes are held should also be treated somewhat differently.

It has often struck me that in such cases subdued general lighting, supplemented by stronger local illumination on the model, is what is needed. The photograph of the Life Room at the Arts and Crafts School is a case in point. Through the courtesy of the Principal this was taken during a recent visit to that institution by Mr. V. H. Mackinney and myself.

The letterpress under the illustration describes the nature of the lighting. The general illumination in the room is about 3–4 foot-candles, an extra illumination of about 25 per cent. where the model stands being provided. Possibly the difference in colour between the general and local lighting would also be an aid in concentrating attention on the model. Presumably even the local light must be well diffused, with a view to avoiding unduly sharp shadows; otherwise one would have thought some form of concentrating reflector preferable.

MR. HAYDN HARRISON (*communicated*): I was very glad to hear Dr. Thompson call attention to the great variation in the colour of daylight. There is such a general impression that daylight is a standard to emulate that it is well people should realise that it varies considerably.

Daylight is generally known as a white light, yet those who have carefully studied the pictures of the best artists will note that the shadows on white objects (such as marble) are rarely painted grey



Life Room at the Arts and Crafts School (Southampton Row, London). Two semi-indirect arc lamps (500-watt) very high up in the extreme corners of the room. Special local lighting for the model is provided by 240-watt tungsten lamps behind diffusing glass, mounted on an adjustable arm.

(a mixture of black and white), as would be the case if the artist were depicting varying degrees of illumination produced by a white light on a white object. This very point accounts for the success of Dr. Thompson's suggestion when he advised the artist to hang up the two arc lamps in the top corners of his north light window and to turn those lamps on during daylight so as to prolong the light for colour purposes; the gradual blending from daylight to arc light would make it difficult to perceive the difference, as the light at sunset is more rich in red rays than an arc lamp.

I was also glad to hear Dr. Thompson point out the objection to too large a light source such as is produced by indirect lighting in a gallery with light walls and ceiling. In a top lighted gallery my experience has gone to prove that a skylight formed of diffusing glass, behind which the artificial lights are turned on to replace daylight, is an ideal arrangement, provided the lamps are sufficiently powerful. For statuary the top light is not always satisfactory, as a great deal more care is necessary to reproduce the conditions of the studio where the statue was produced. Therefore it is often found advisable to treat each piece of statuary separately. In other words to provide it with a separate light source, and it will be remembered that such treatment has often proved satisfactory in the case of pictures, provided they can be set back in some suitable recess so that the lights are invisible.

Professor Silvanus P. Thompson, in replying to the discussion, said that thanks were due to Mr. Murray for his contribution to it, because there were many things that he said which they would all remember. He was interested in Mr. Murray's remark that the yellows and violets were more difficult to manage for artificial light than the greens. He had no doubt that Mr. Murray was right from his own point of view; and Mr. Ritchie had also said that in the textile industry yellows appeared to give more trouble. That was probably related to the observation of Lord Rayleigh when he pointed out, ten years ago, that in the gradual change from one colour to another, in the spectrum, the eye more readily detected a change in the yellow than a change in any other colour; but, be that as it might, his own remark that greens were more difficult arose from the fact that he had found, and Mr. Trotter also, that the greens were so perplexingly complex in their spectra. They might look exactly alike under one illumination, but with a very slight change in the illumination these greens might be totally different. Apparently it was something to do with the absorption bands in the pigments that were employed.

Then they had to thank Mr. Joseph Pennell for his brilliant contribution to the discussion. He entirely agreed with Mr. Pennell that the problems of studio and gallery were different matters. They were both of them involved in the lighting of pictures, and in that sense they were the same thing; but as practical problems they were entirely different. Indeed, he thought he had only likened them together in one respect, and that was in saying that in whatever direction the daylight came, we should attempt to have the same direction for the artificial illumination, if it were desired to have anything like the same effect by night as by day. Mr. Pennell's remarks about the use of a horizontal screen or "velarium" to cut off the direct light constituted probably the most important contribution to the discussion. The effect of putting a screen or a veil, which could be raised or lowered in the way suggested, he was not aware of; he was ashamed to say it, but perhaps there were others equally unenlightened.

Mr. V. H. Mackinney had not done justice to himself in describing his new system of lighting. Anybody could put a row of lamps behind a screen above a picture; but an ordinary reflector simply stuck up in front of a picture would throw at least three times as much light on to the top of the picture as the bottom. Now Mr. Mackinney had achieved a uniform lighting from top to bottom; and that had not been accomplished without a great deal of thought and mathematics, and time spent to discover the particular helicoidal curve of the reflector which would produce this result. He considered this a new departure in geometrical

optics, and one of very great importance where it was desired to have a uniform illumination all over the picture, such as would be obtained if one were working out in the open air.

He had intended to say a little more than he did on one point, and that was to point out, to whomsoever it might concern, the extremely simple nature of the real step that has been made in getting a whiter light—the finding of a bluish-green glass which so far fulfilled the conditions as to give a step towards daylight illumination. This was now a matter entirely at the service of the public, because these bluish-green lamps were available on the market. They were not made by any one particular firm, but by various firms. He had in his own house an unpretending picture gallery, and he had been using these bluish-green lamps to the great advantage of whatever pictures there might be in this room, and also in one of his living rooms. Three of the companies employed in the manufacture of electric glow lamps, namely, the General Electric Company, who furnished the Osram lamps, kindly placed some of their daylight lamps at his disposal; Messrs. Siemens Bros. provided him with some daylight lamps; and the Chief Engineer of the Edison and Swan lamp factory had taken much trouble to find him exactly the thing he wanted; and now the B.T.H. Company was doing the same thing with their Mazda daylight lamps. Anyone could now order daylight lamps to suit any voltage, of practically any candle-power, and could so get the benefit, for such it truly was, of this form of illumination. He desired to thank these companies for the assistance they had given him. His own part in this discussion had been extremely small. He had merely had to state the problems, and to stir up those who had views on the matter to express them. He thought he had succeeded in stirring up valuable expressions of opinion. He hoped that we should soon have directors and trustees of picture galleries brought to a sense of their responsibility in the matter of the due lighting of picture galleries.

THE CHAIRMAN, in proposing a vote of thanks to Professor Thompson, said the Illuminating Engineering Society was very greatly indebted to his sympathy and support, and it was a very great personal regret to think that this was the last occasion upon which we should have a paper from him in his position as President. Time, however, was still young, and they might hope that he would later on join them again in that capacity. He formally proposed a very sincere vote of thanks to Professor Thompson for so kindly coming, at great trouble, to give the most interesting opening to the discussion that he had done. He also proposed a vote of thanks to those makers who had sent samples of lamps to exhibit, and to Mr. Macdonald and Mr. Oldrieve for information on the lighting of galleries in Glasgow and Edinburgh.

[The exhibit included an arrangement (provided by the British Thomson Houston Co.) enabling an ordinary tungsten lamp and a daylight lamp to be switched on successively, so as to illuminate some pictures kindly brought to the meeting by Prof. Thompson. Messrs. Siemens Bros. sent a cabinet enabling a comparison to be drawn between the effect of an ordinary tungsten lamp and one with a special "daylight" glass bulb. The Benjamin Electric showed a cabinet equipped with the daylight screen designed by Dr. Kenneth Mees. A picture was also shown illuminated by the Holophane Uniflux reflector.]

STREET LIGHTING IN LIVERPOOL.

IN a recent number of the *Gas World* a brief reference is made to the annual report of the Liverpool Corporation's Lighting Engineer.

The total length of roads lighted in the city, irrespective of courts and passages, amounted to 499¼ miles. Of this 8 miles are lighted by electricity, 475¼ by incandescent gas, 11 by flat-flame burners, and—curious to relate—5 by oil.

A COMPARISON OF ESTIMATED AND OBSERVED VALUES OF ILLUMINATION IN SOME LIGHTING INSTALLATIONS

(PROCEEDINGS AT A MEETING OF THE ILLUMINATING ENGINEERING SOCIETY HELD AT THE HOUSE OF THE ROYAL SOCIETY OF ARTS, 18, JOHN STREET, ADELPHI, LONDON, ON TUESDAY, MARCH 17TH, 1914.)

A MEETING of the Society took place as announced above on Tuesday, March 17th, Mr. F. W. GOODENOUGH being in the chair.

The Minutes of the last Meeting having been taken as read, the Hon. Secretary read out the names of applicants for membership in the usual way.

The Chairman then called upon Mr. W. C. CLINTON to read his paper entitled "**A Comparison of Estimated and Observed Values of Illumination in some Lighting Installations.**" A discussion followed in which Mr. A. P. TROTTER, Mr. L. GASTER, Mr. J. G. CLARK, Mr. J. DARCH, Mr. V. H. MACKINNEY, Mr. T. E. RITCHIE, Mr. WILLIS, Mr. LOVIBOND, Mr. J. ECK and Mr. J. S. Dow took part.

Mr. CLINTON briefly replied to the discussion, and in conclusion THE CHAIRMAN moved a very cordial vote of thanks to Mr. Clinton for his paper, and to those who had contributed to the interest of the evening by furnishing data embodied therein.

In conclusion THE CHAIRMAN announced that the next meeting of the Society would take place on Tuesday, April 7th, when a discussion on the "Lighting of Railway Carriages and other Public Vehicles" would be opened by Mr. E. KILBURN SCOTT.

NEW MEMBERS OF THE SOCIETY.

THE names of applicants for membership read at the previous meeting on Feb. 17th* were read again at the last meeting on March 17th, and these gentlemen were formally declared members of the Society.

In addition the names of the following gentlemen have been duly submitted and approved by the Council and were also read out by the Hon. Secretary at the last meeting :—

Gulland, W. D.	Deputy Superintendent, Street Mains and Lighting Department, Town Hall, MANCHESTER.
Walsh, J. W. T., B.Sc., B.A. (Oxon.)	Observer to Home Office Committee on Factory Lighting, 5, Haggard Road, TWICKENHAM.
Weiss, A., A.M.I.E.E.	Electrical Engineer, General Electrical Company, Osram Lamp Department (Technical Section), 1, Highbury Hill, LONDON, N.

* *Illum. Eng.*, March, 1914, p. 147.

OFFICIAL ANNOUNCEMENT OF NEXT MEETING.

(To be held in the House of the Royal Society of Arts, 18, John Street, Adelphi, London, at 8 p.m., on Tuesday, April 7th, 1914.)

At this meeting a discussion on **"The Lighting of Railway Carriages and other Public Vehicles"** will be opened by **Mr. E. Kilburn Scott.**

Tickets can be had on application to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.).

ROYAL INSTITUTE OF PUBLIC HEALTH.

ANNUAL CONGRESS, TO BE HELD IN EDINBURGH, JULY 15TH—20TH, 1914.

Our attention is drawn to the Annual Congress of the Royal Institute of Public Health, which is to be held in Edinburgh, as announced above, upon the invitation of the Right Hon. the Lord Provost and the City Council.

It will be recalled that at the last Annual Congress, held in Paris last year, a special section on Industrial Hygiene, in which illumination received special attention, was arranged. At the coming Congress, Industrial Hygiene will again be discussed under the presidency of Sir Thos. Oliver. It is hoped that the Illuminating Engineering Society will be officially represented on this occasion also, and the proceedings will doubtless be of interest to many members of the Society.

Those desiring to be present should apply to the Hon. Secretary-General of the Congress, A. CORBETT SMITH, ESQ., RUSSELL SQUARE, LONDON, W.C.

INTERNATIONAL MARINE, NAVAL HYGIENE AND ITALIAN COLONIES EXHIBITION.

TO BE HELD IN GENOA, MARCH—NOVEMBER, 1914.

We have received from Prof. S. A. Rumi (corresponding member of the Illuminating Engineering Society in Genoa) particulars of the Marine Exhibition which is shortly to be opened in that city. Prof. Rumi expresses the hope that the exhibition will be of interest to many members of the Society. There will be a special section devoted to illuminating apparatus, and Genoa, as the chief port in Italy, lends itself particularly well to an exhibition of this kind. Other sections deal with such matters as harbour administration, wireless telegraphy, fisheries, emigration, &c., in addition to the matters more strictly relating to shipping and naval architecture.

Members of the Society who would like to be present at the exhibition, or to exhibit apparatus, should apply for fuller particulars to Prof. S. A. Rumi, 3B, Via S. Luca, GENOA, or to the EXECUTIVE COMMITTEE, Via XX. Settembre, 34-3 Genoa.

MACHINE TO REGISTER FATIGUE.

According to the *Globe*, M. J. M. Laby, member of the French Academy of Sciences, in a communication to the Academy, has declared that he had devised practical means of scientifically determining the degree of fatigue entailed by modern professions. Experiments carried out since 1903 on post office sorters, printers, linotype operators, and typists, had given absolutely concordant results. The degree of fatigue was determined by the increase in the arterial pressure and the time of the subsequent reaction.

It would certainly be interesting to ascertain whether this instrument could be applied to determine the comparative conditions of fatigue resulting from the use of various methods of illumination.

By some such test we might gradually find out which are the defective conditions of lighting that cause fatigue and add to the strain of industrial occupation.

A COMPARISON OF ESTIMATED AND OBSERVED VALUES OF ILLUMINATION IN SOME LIGHTING INSTALLATIONS

By W. C. CLINTON, B.Sc.

Paper read at a Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m., on Tuesday, March 17th, 1914.

THE object of this paper is to institute a comparison between results actually attained in artificial lighting installations, and their predetermination from known data of the types of illuminants used.

The resultant horizontal illumination on the working plane in foot-candles will be considered in all cases, the comparison being between this quantity as calculated for given positions and the values obtained by photometry at the same positions.

For a source sufficiently small to be regarded as a point, and having a given polar curve, well-known rules will give at once the horizontal illumination at a point due to such a source. The sum of these values taken for all the sources installed will give the total horizontal illumination at the point.

This is the value that would be found if the walls of the room were indefinitely far away or were perfectly black. If walls having a given coefficient of reflection are imagined to move in closer and closer to the lights, then the horizontal illumination will be increased more and more by reflection from them, of portions of the total flux of light from the lamps which before escaped without affecting the illumination at the point considered. The amount by which the illumination is thus increased will depend on three things :—

(A) The colour and texture of the wall and ceiling surfaces as determining their coefficients of reflection. Floor surfaces are usually dark and their effect may be neglected.

(B) The dimensions of the room compared with the area enclosed by the light sources.

(C) The nature of the polar curve. A curve with great lateral extension will give a horizontal illumination of which a greater percentage is due to reflection from the walls than would be the case where most of the light is directed downwards.

The above-mentioned point by point method of calculation will therefore give in general lower values of the horizontal illumination than those observed, the difference diminishing as the effect of walls and ceiling are made less and less, either by their colouring or their distance from the lights. Apparent exceptions may arise, but it will always be found that if the calculated values by this method are higher than those observed, the conditions in the data assumed are not fulfilled in the installation.

The "flux of light" method enables one to deduce the total flux of light shed by each source on the floor, and so arrive directly at the mean horizontal illumination.* If the flux going to the walls and ceiling be neglected, the mean horizontal illumination arrived at in this way should agree with that deduced by the first method provided that a sufficiently large number of points are selected, correctly disposed over the area.

The calculations are quickly made, but the analysis of the distribution of light afforded by the more laborious point by point method is wanting.

A third procedure is to calculate from the polar curve the total flux of light liberated in the room, and then to compare the mean horizontal illumination

* Dr. L. Bloch, Grundzüge der Beleuchtungstechnik, English translation, p. 61.

that would be produced if the whole of this flux arrived on the plane of reference, with that actually measured. In those cases where this has been done, the value of the total flux up to any angle from the vertical has been arrived at graphically from the polar curve by Dr. Kennelly's construction.*

considerable distance above the reflectors. The reflectors themselves are made of aluminium, with a matt reflecting surface, and are opaque. Each lighting point is fitted with a 200-watt tungsten lamp in a clear bulb.

The polar curve of the lamp and reflector is given in Fig. 2, together with

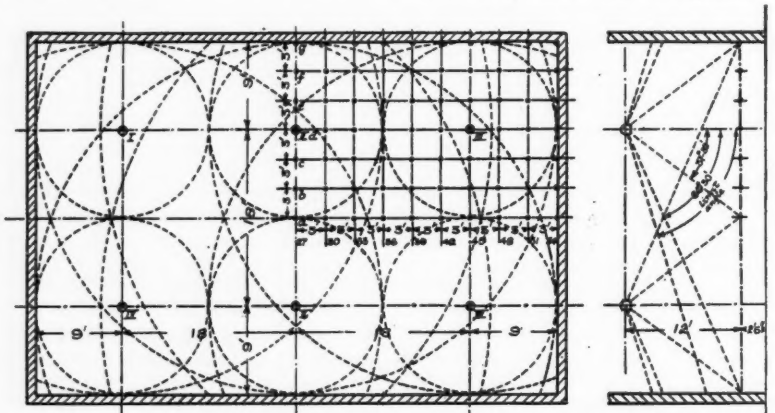


FIG. 1. PLAN AND SECTION OF ROOM SHEWING POSITION OF LAMPS AND TEST STATIONS. EACH LIGHTING POINT IS FITTED WITH ONE 200 WATT TUNGSTEN LAMP IN CLEAR GLASS BULB WITH REFLECTOR, THE COMPLETE UNIT HAVING THE POLAR CURVE OF FIG. 2

The ratio,

$$\frac{\text{total flux sent on to the reference plane}}{\text{total flux from source}}$$

or which is the same thing,

$$\frac{\text{mean horizontal illumination observed}}{\text{mean horizontal illumination due to total flux}}$$

might perhaps be termed the utilisation factor of the installation. To get the total utilisation of the light produced by the source without any shade the above factor would have to be multiplied by another giving this ratio for the fitting itself.

(1) *Lighting of a Workshop with Tungsten Lamps in Metal Reflectors.*

As an example, the lighting of a workshop whose plan and cross-section are shown in Fig. 1 will be considered.

This shop was new and empty when the measurements were taken. The walls are of a light tint with a dark dado, and the roof is of the saw-tooth pattern, at a

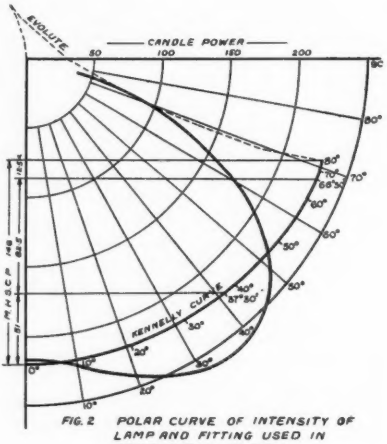


FIG. 2. POLAR CURVE OF INTENSITY OF LAMP AND FITTING USED IN ROOM SHEWN IN FIG. 1

the deduced Kennelly curve. The horizontal illumination due to each one of the six lamps at each of the 54 test stations shown in Fig. 1 has been calculated, and the sum taken of the six lamp values for each point. As a specimen of

* American Illuminating Engineering Society, Feb. 18, 1908, and *Electrical World*, New York, Vol. 51, p. 645, 1908.

TABLE I.

Detailed Illumination Values for Lamp III. (Fig. 1.)

Position.	Sq. of total dist.	Total dist.	Cos. $= \frac{h.}{\text{Total dist.}}$	θ	I from curve.	Hor. illum. at pt. in ft.-candles
27 g and a	549	23·4	0·513	59° 5′	182	0·17
30 „	450	21·2	0·567	55° 30′	205	0·253
33 „	369	19·2	0·626	51° 20′	230	0·39
36 „	306	17·5	0·687	46° 40′	245	0·55
39 „	261	16·25	0·740	42° 15′	250	0·71
42 „	234	15·6	0·771	39° 40′	260	0·856
45 „	225	15·0	0·80	36° 50′	260	0·925
48 „	234	15·6	0·771	39° 40′	260	0·856
51 „	261	16·25	0·740	42° 15′	250	0·710
54 „	306	17·5	0·687	46° 40′	245	0·55
27 f and b	504	22·45	0·534	57° 40′	190	0·201
30 „	405	20·15	0·596	53° 30′	220	0·324
33 „	324	18·0	0·667	48° 10′	240	0·494
36 „	251	15·85	0·758	40° 40′	260	0·785
39 „	216	14·7	0·816	35° 20′	260	0·983
42 „	189	13·75	0·874	29° 10′	257	1·19
45 „	180	13·40	0·896	26° 30′	250	1·245
48 „	189	13·75	0·874	29° 10′	257	1·19
51 „	216	14·7	0·816	35° 20′	260	0·983
54 „	251	15·85	0·758	40° 40′	260	0·785
27 e and c	477	21·8	0·552	56° 35′	200	0·232
30 „	378	19·42	0·618	51° 50′	230	0·376
33 „	297	17·25	0·697	45° 50′	250	0·587
36 „	234	15·3	0·793	37° 30′	260	0·88
39 „	189	13·75	0·874	29°	257	1·19
42 „	162	12·72	0·945	19°	240	1·40
45 „	153	12·37	0·97	14°	230	1·46
48 „	162	12·72	0·945	19°	240	1·40
51 „	189	13·75	0·874	29°	257	1·19
54 „	234	15·30	0·793	37° 30′	260	0·88
27 d	468	21·6	0·556	56° 15′	200	0·237
30 „	369	19·2	0,626	51° 20′	230	0·391
33 „	288	17·0	0·707	45°	252	0·619
36 „	225	15·0	0·80	36° 50′	260	0·925
39 „	180	13·42	0·895	26° 30′	250	1·245
42 „	153	12·37	0·97	14°	230	1·455
45 „	144	12·0	1	0	215	1·492
48 „	153	12·37	0·97	14°	230	1·455
51 „	180	13·42	0·895	26° 30′	250	1·245
54 „	225	15·0	0·80	36° 50′	260	0·925

such a calculation, the table for Lamp III. is given, and the final table for the long centre line of the room, showing the method of collecting values together.

In all these tables, h=vertical height of lamp above reference plane, θ=angle from vertical of line joining lamp with point considered, and I=intensity in candle-power in this direction read off from the polar curve. The horizontal illumination in the last column is calculated from the equation,

$$\text{horizontal illumination} = \frac{\text{I} \cos \theta}{(\text{total distance})^2}$$

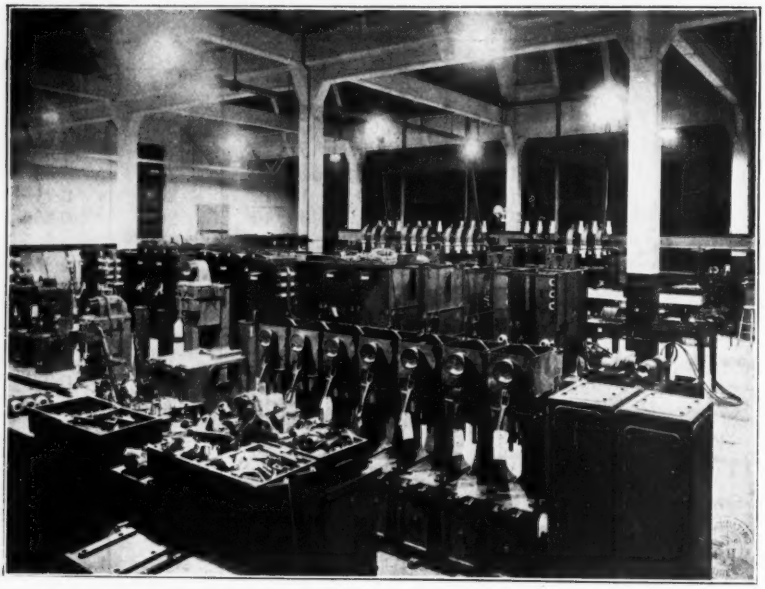
an expression equivalent to

$$\frac{\text{I} \cos^3 \theta}{(\text{vertical height})^2}$$

a form in which it is very often stated.

Figures 3, 4, and 5 give calculated and observed illumination curves, the excess of the observed values being due to the additional light obtained by reflection from the walls. There is no flux above 75°, and the reflection from the roof is negligible.

The mean of all the calculated values of the horizontal illumination is 2 foot-candles almost exactly. In deducing this the stations along the boundary of the area were weighted to only half the value of those in the centre. This compares with 2·5 foot-candles, the average of the observations, giving a gain of 0·5 foot-candle or 25 per cent. due to reflection from the walls.



I.—Workshop lighted by tungsten lamps in metal reflectors.

The lighting of this room was next examined by considering the total flux which reaches the plane of reference only. The circles described around the lamp points as centres in Fig. 1 show the zones taken, the corresponding angles of elevation being marked on the polar diagram (Fig. 2). There is some approximation necessary in dealing with the corners. The results are :—

Flux in lumens from Lamps I., III., IV., and VI.=584×4=2336.

Flux in lumens from Lamps II. and V.=691×2=1382.

Total flux on reference plane=3718.

TABLE II.

Summation of Results. Fig. 1.

Lamp.	27a.	30a.	33a.	36a.	39a.	42a.	45a.	48a.	57a.	54a.
I.	0·168	0·113	0·0714	0·0511	0·0287	0·0198	0·1441	0·0107	0·0079	0·0045
II.	0·930	0·857	0·732	0·561	0·390	0·229	0·168	0·1135	0·0742	0·0498
III.	0·17	0·253	0·390	0·55	0·71	0·856	0·925	0·856	0·710	0·550
IV.	0·168	0·109	0·0709	0·048	0·0287	0·0201	0·0142	0·00985	0·00676	0·00507
V.	0·925	0·880	0·740	0·560	0·390	0·246	0·168	0·112	0·082	0·049
VI.	0·168	0·259	0·389	0·55	0·726	0·88	0·925	0·88	0·726	0·55
Totals	2·529	2·471	2·393	2·320	2·273	2·251	2·314	1·982	1·607	1·209

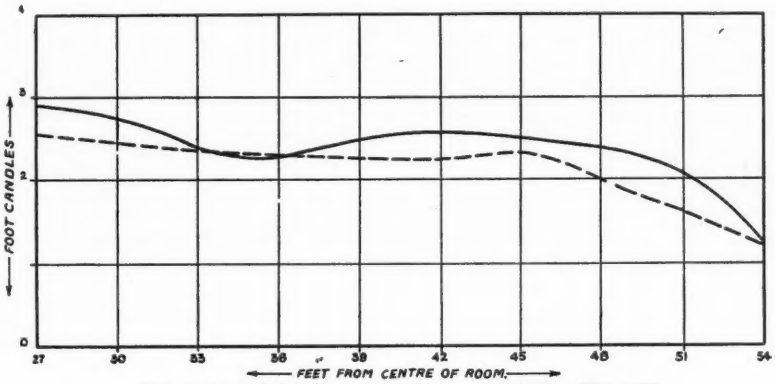


FIG 3 ILLUMINATION ON LINE a FIG 1. OBSERVED—FULL LINE
CALCULATED—DOTTED LINE

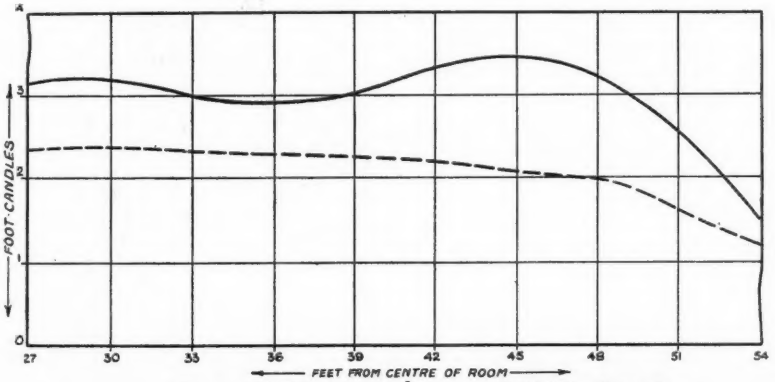


FIG 4 ILLUMINATION ON LINE a FIG 1 OBSERVED—FULL LINE
CALCULATED—DOTTED LINE

The floor area is 1940 sq. ft., hence the mean horizontal illumination in foot-candles is

$$\frac{3718}{1940} = 1{\cdot}91$$

a figure in close agreement with that obtained by the first method, the exact value of which was 1·97 foot-candles. The mean hemispherical candle-power is 146, hence the total flux liberated in the room is given as—

$$2\pi \times 146 \times 6 = 5520 \text{ lumens,}$$

sufficient to produce a mean horizontal illumination of $\frac{5520}{1940} = 2{\cdot}85$ foot-candles if the whole of it were directed on to the plane of reference.

The utilisation factor is therefore $\frac{250}{285}$ or 88 per cent. Taking the mean of the calculated values of the mean horizontal illumination, the total flux arriving directly from the lamps on to the reference plane is $1{\cdot}94 \times 1940 = 3760$ lumens. The light shed on to the walls is therefore,

$$5520 - 3760 = 1760 \text{ lumens.}$$

No light goes directly to the roof, and there are no windows round the walls. Hence the whole of this difference is partly reflected and partly absorbed by the walls. The observed increase over the direct flux is the difference,

$$4850 - 3760 = 1090 \text{ lumens}$$

Neglecting light reflected from the walls on to the roof, the coefficient of reflection of the walls is,

$$\frac{1090}{1760} = 62\%$$

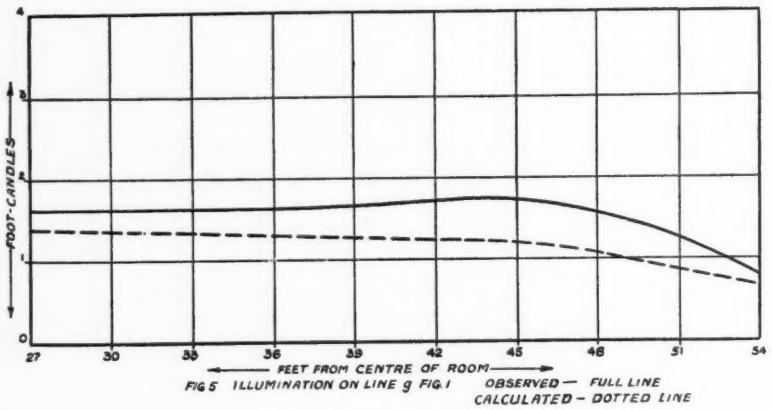


FIG 5 ILLUMINATION ON LINE g FIG 1

This figure is under the value given by L. Bloch for lightly coloured walls, but the difference can be accounted for by the presence of the dark dado.

A Drill Hall lighted by Tungsten Lamps in Metal Reflectors.

Fig. 6 shows the plan of a drill hall lit by ten clusters of lamps, each cluster consisting of four 100-watt lamps, with steel reflectors over each lamp, the combined lamp and reflector giving the polar curve shown in Fig. 7. From this curve, and the dimensions of room, the walls would not be expected to produce any great effect on the illumination at points a, b, c, d, and an examination by the point to point method shows this to be the case. The tabulation for the point d is appended, the calculations being made for the floor level

TABLE III.

Horizontal Illumination at point d. on Plan of Drill Hall (Fig. 6).

Lamps.	Square of total dist.	Total dist.	Cos θ	θ	I.	Hor. illum.
I. and VI.	4316	65·7	0·2385	76° 15′	50	·0028
II. and VII.	2370	48·7	0·322	71° 15′	75	·0105
III. and VIII.	346	18·6	0·844	35°	512	1·245
IV. and IX.	1421	37·7	0·416	65° 25′	200	·0586
V. and X.	4506	67·1	0·234	76° 30′	50	·0026
					2 ×	1·3195
					=	2·64 f.c.

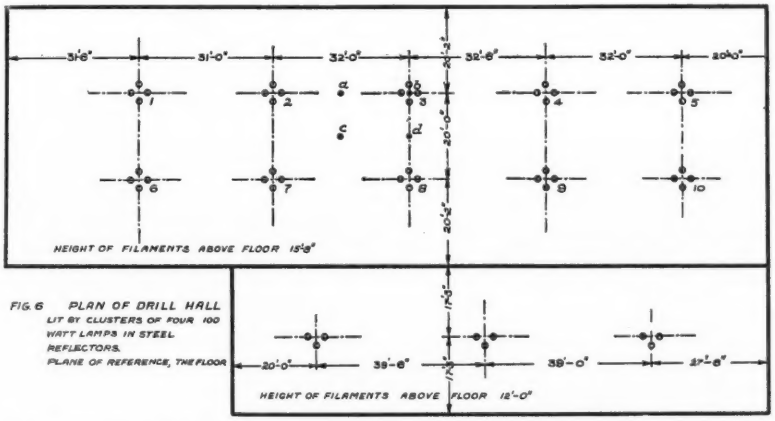


FIG. 6 PLAN OF DRILL HALL LIT BY CLUSTERS OF FOUR 100 WATT LAMPS IN STEEL REFLECTORS. PLANE OF REFERENCE, THE FLOOR

The comparison for the four points is given in Table IV.

TABLE IV.

Comparison of Results. Fig. 6.

	a.	*b.*	*c.*	*d.*
Calculated values	2·13	2·11	2·51	2·65
Observed values	2·1	2·2	—	2·75

Using the flux of light method, the total flux is,

$$282 \times 10 \times 2\pi = 17700 \text{ lumens.}$$

If this were all delivered on the reference plane, which is in this case the floor, having an area of 10,800 sq. ft., the mean horizontal illumination would be,

$$\frac{17700}{10800} = 1{\cdot}7 \text{ foot-candles.}$$

The observations taken were not systematic enough to allow of the determination of a mean value for the whole floor, so that the utilisation factor cannot be arrived at with certainty.

The utilisation factor of the fitting itself can be approximately determined from the Kennelly curves in Fig. 2 and Fig. 7. Taking 0·65 mean spherical candle-power per watt as the figure for tungsten lamps burning at normal voltage in clear bulbs, in Fig. 2 the total flux from lamp alone is,

$$0{\cdot}65 \times 200 \times 4\pi = 1634 \text{ lumens.}$$

The total flux from lamp and fitting is, $146 \times 2\pi = 917$ lumens, hence the utilisation factor

$$= \frac{917}{1634} \text{ or } 56\%$$

In Fig. 7 the total flux from lamp is

$$\cdot 65 \times 400 \times 4\pi = 3268 \text{ lumens,}$$

and the total flux from lamp and shade is, $282 \times 2\pi = 1770$ lumens, and the utilisation factor,

$$= \frac{1770}{3268} = 54\%$$

A study of the tables in these two cases brings out the well-known fact that the horizontal illumination between two sources is determined very largely by those sources, so that if they are spaced apart pair and pair at a distance which for the height gives approximately constant illumination between them, then

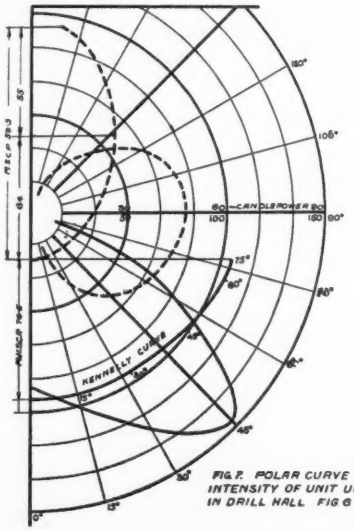


FIG 7. POLAR CURVE OF INTENSITY OF UNIT USED IN DRILL HALL FIG 6

II.—Drill Hall lighted by tungsten lamps in metal reflectors.

the whole floor area will have a rather greater, but also an approximately constant, illumination. The distance apart for a given height or the ratio of height to distance to secure this result will depend on the shape of the polar curve used. These are the considerations which have led to the formation of those "spacing rules" now coming into general use.

(3) *A Church lighted by Tungsten Lamps in Prismatic Glass Reflectors.*

An example of the use of prismatic reflectors with tungsten lamps giving a very strong downward illumination is shown in Fig. 8, which gives the distribution of lighting points in a church.

Each of the ten points over the body of the church consists of three 55-watt lamps with prismatic reflectors suspended from a metal band 3 feet in diameter, each lamp and reflector having the polar curve shown in Fig. 10. Owing to the presence of the gallery on three sides, it

TABLE V.

Summary of Results. Fig. 8.

Position.	Illumination in ft.-candles.	
	Calculated.	Observed.
A	2·53	2·5
B.	2·96	3·0
C.	3·27	3·0
D.	3·78	3·5
E.	3·41	3·0
F.	3·96	3·5

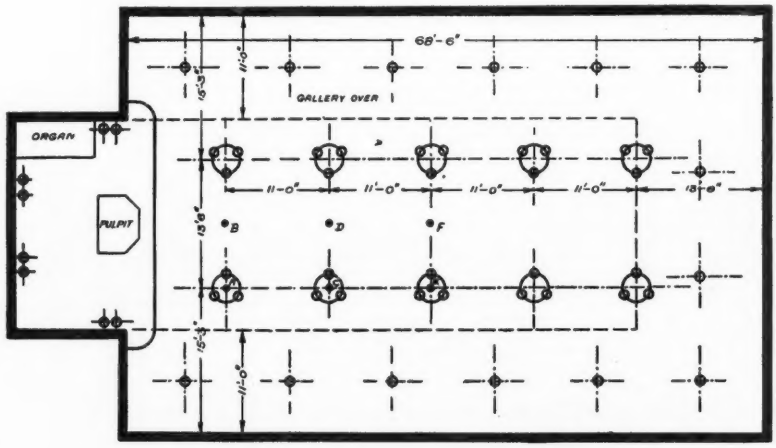


FIG. 8 PLAN OF CHURCH LIGHTING 55 WATT LAMPS IN PRISMATIC REFLECTORS

was difficult to make a satisfactory computation of the mean horizontal illumination by the flux of light method, but, on the other hand, the point by point method applied to the points A B C D E F was easily worked out, as the lamps are symmetrically disposed with regard to these positions. Tables were made out in the manner already indicated, and the final summary is given in Table V.

The calculated results at points D and F are in accordance with what might be expected, as the lamps are closer together than they would have been if the spacing rule applicable to them for securing even illumination had been adhered to, and it is also evident that reflection from the walls has no effect in increasing the illumination.

A rough estimate was made of the whole flux of light coming down on to the galleries and the central area, from the angles shown in Fig. 9.

Referring to the polar diagram, Fig. 10, the total flux from lamp and shade is $39 \times 4\pi = 490$ lumens.

The mean of the angles subtended by the top of the gallery at the lamps on the two sides is about 70°, and the total flux under this angle is $2\pi \times 50{\cdot}5 = 317$. Hence the utilisation factor is,

$$\frac{317}{490} = 65\%$$

Doubtless, however, the light in the upper hemisphere, which has been neglected in this estimate, is useful in preserving the roof from complete darkness.

III.—Church lighted by tungsten lamps in prismatic glass reflectors.

A value of the mean horizontal illumination over the central area, which will be rather an under-estimate, can be obtained by considering the lights moved on to the long centre line of the church, and the flux in the angle determined by the corners of the galleries calculated.

The flux per point within this angle is

$$30 \times 3 \times 2\pi = 560 \text{ lumens.}$$

For 8 points the flux is $8 \times 560 = 4480$ lumens, and for 2 lamps, which are on the edge of the area, the flux is $2 \times 280 = 560$ lumens.

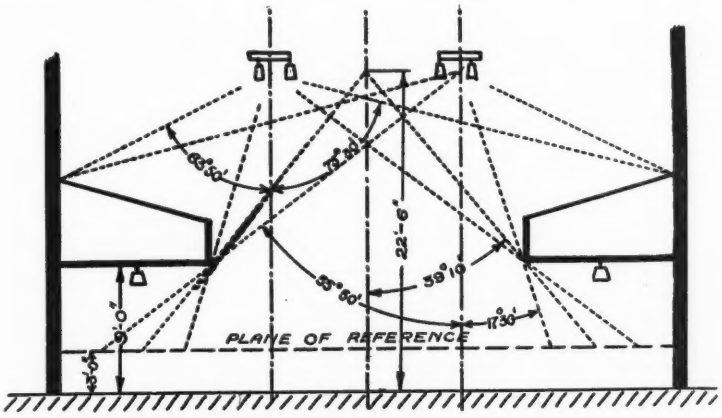


FIG. 9 SECTION OF CHURCH TO SHEW METHOD OF ESTIMATING MEAN HORIZONTAL ILLUMINATION.

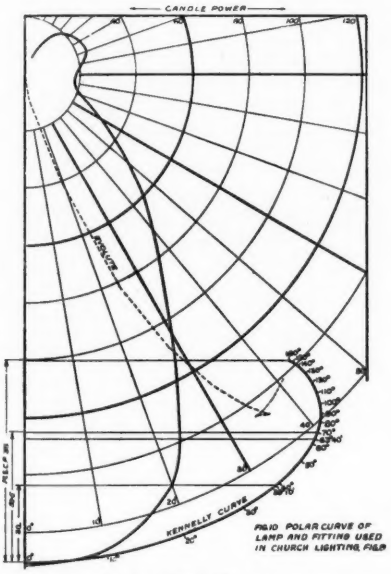


FIG. 10 POLAR CURVE OF LAMP AND FITTING USED IN CHURCH LIGHTING FIELD

This angle is 39° 10′, giving an area on the reference plane of approximately 1700 square feet.

The total flux is $4480 + 560 = 5040$ lumens. Hence the mean horizontal illumination is

$$\frac{5040}{1700} = 2{\cdot}95 \text{ foot-candles.}$$

The effect of the lamps being hung on a ring 3 feet in diameter was examined, and the difference in illumination due to this disposition from that obtained on the supposition that all three lamps are at the centre of the ring was found to be negligible.

(4) *A Railway Booking Hall lighted by Tungsten Lamps in Prismatic Glass Reflectors.*

Another example of lighting by tungsten lamps with prismatic reflectors is afforded by the case of the railway booking hall shown in Fig. 11. At each point there is a 200-watt lamp with shade, the unit having the polar curve shown in Fig. 12. Here again the units are closer together than the spacing rule for the type would allow, with the result that, as in the case of the church, the calculated

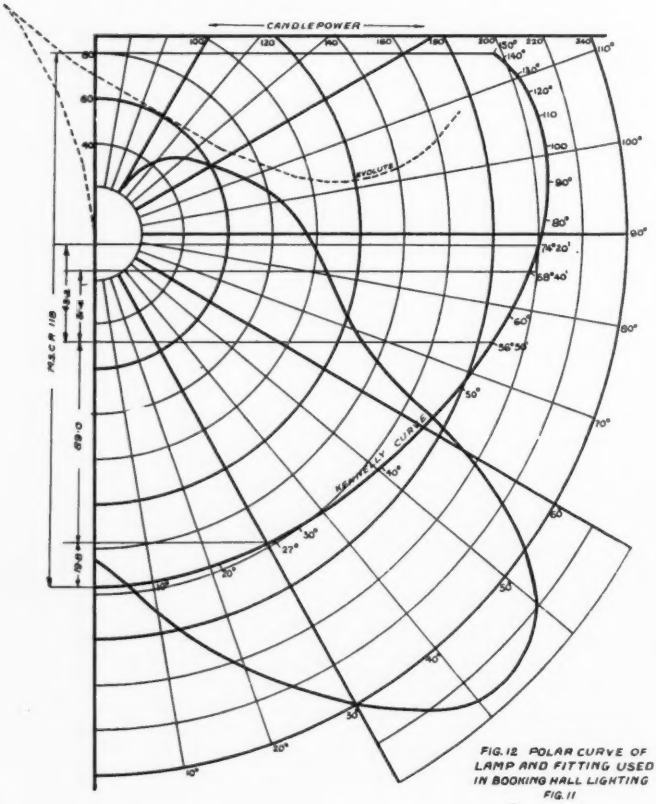
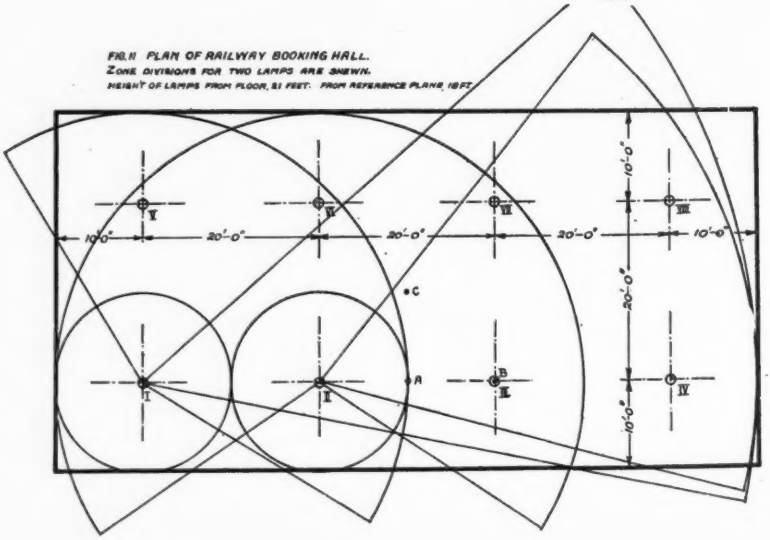


FIG. 12 POLAR CURVE OF LAMP AND FITTING USED IN BOOKING HALL LIGHTING FIG. 11

FIG. 11 PLAN OF RAILWAY BOOKING HALL.
ZONE DIVISIONS FOR TWO LAMPS ARE SHEWN.
HEIGHT OF LAMPS FROM FLOOR, 21 FEET. FROM REFERENCE PLANE 10 FT.



values show a heaping up of the illumination towards the middle of the room. The figures are given in Table VI.

TABLE VI.

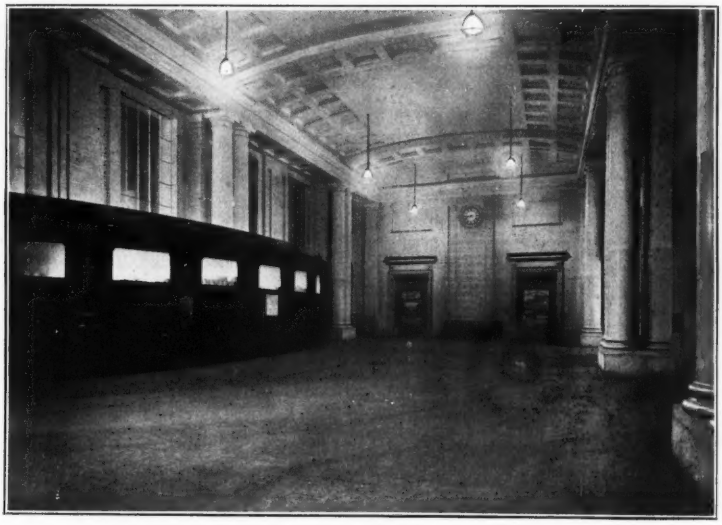
Comparison of Results. Fig. 11.

Position.	Calculated value of horizontal illumination.	Observed values.
A.	1·60	1·5
B	1·44	1·5
C.	1·88	1·5

falling off in illumination in a space of 18 days' continuous use varies from 18·5 per cent. to 45 per cent., depending on the conditions of service.

The estimation of the mean horizontal illumination by the flux method is in this case particularly easy. The symmetrical arrangement of the points, and the flat plane of reference, neglecting the actual booking office, make it unnecessary to draw cones for more than two lamps, as shown in Fig. 11. The summation is shown in Table VII.

Hence flux for 8 lamps=$4\times951\cdot3=$ 3805 lumens.



IV.—Railway Booking Hall lighted by tungsten lamps in prismatic glass reflectors.

Observations were taken over the central area of the room some days after the installation was put in, and readings of about 1·5 foot-candles were obtained. In this case also, reflection from the walls does not appear to count for anything, although it should be remembered that ageing effects set in quite rapidly, as has been shown in some results recorded by Clewell * and shown in Fig. 13, where the

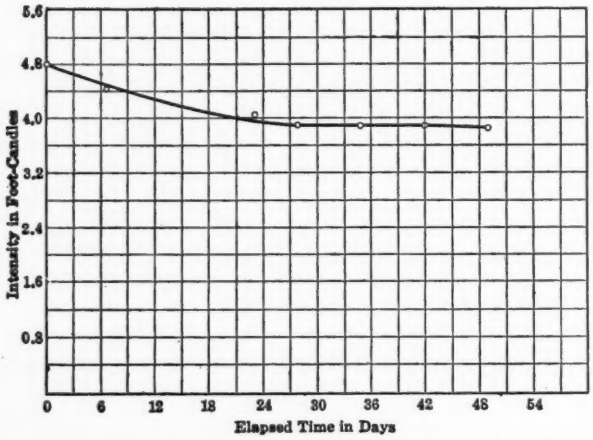
The area of the plane of reference is 3200 sq. ft., giving a mean horizontal illumination of $\frac{3805}{2200}=1\cdot18$ foot-candles.

The total flux from the lamps is $8\times4\pi\times118=11900$.

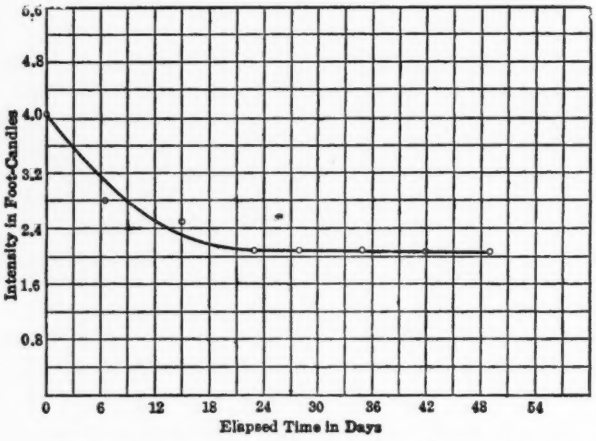
Hence the utilisation factor is

$$\frac{3805}{11800}=31\%$$

* C. E. Clewell, *Factory Lighting*, pp. 48 and 49.



—Deterioration curve showing effect of dust and dirt accumulations on glass reflectors. (Office.)



—Deterioration curve showing effect of dust and dirt accumulations on glass reflectors. (Factory.)

FIG. 13.—Showing deterioration of illumination through dust. (From *Factory Lighting*, by C. E. Clewell.)

This figure is, however, not of much use in this particular instance, as the object was to light the walls and notice boards as much as the floor.

5 foot-candles on the desks, slightly below the calculated values in Table VIII.

The mean hemispherical candle-power from Fig. 15 is 113·5, so that, neglecting the upper hemisphere, the light put forth into the room is

$$2\pi \times 113{\cdot}5 \times 5 = 3570 \text{ lumens},$$

which if it were all shed on to the plane of reference of 575 sq. ft. would give an average illumination of

$$\frac{3570}{575} = 6{\cdot}2 \text{ foot-candles.}$$

TABLE VII.

Flux of Light Determination. Fig. 11.

		Portion of circumference in degrees.	Sine angle of cone.	Flux of light in lumens.
Lamp I.	First cone	360°	270°	124
	Second cone	154°	56° 50′	237
	Third cone	52°	74° 20′	52·7
Lamp II.	First cone	360°	27°	124
	Second cone	245°	56° 50′	376
	Third cone	69·4°	68° 40′	37·6
		Flux for two lamps		951·3

(5) *A Schoolroom lighted by Incandescent Gas (Low Pressure).*

In the class room of an elementary school, where inverted gas burners with suitable shades were installed and spaced as shown in Fig. 14, point by point calculation for points immediately under the lamps, and for the corners and middle of the sides of the room, gave the following figures :—

TABLE VIII.

Summary of Calculated Values. Fig. 14.

Position.	Illum. in f.c.	Position.	Illum. in f.c.	Position.	Illum. in f.c.
I.	5·5	A.	0·61	E.	2·46
II.	5·5	B.	1·50	F.	1·99
III.	5·5	C.	0·98	G.	1·65
IV.	5·5	D.	0·51	H.	0·84
V.	6·6				

The tabulation for the point A is given below in Table IX , and the polar curve of the combined unit is shown in Fig. 15. Actual test under the lamps gave about

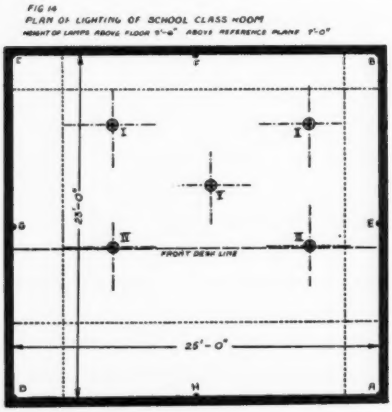
The mean value calculated from the results of Table VIII. is approximately

$$\frac{2100}{575} = 3{\cdot}7 \text{ foot candles.}$$

TABLE IX.

Detailed Illumination Values for Position A. Fig. 14.

Lamp.	Total dist.	Total dist.	Cos. θ	θ	I.	Nor. illum.
I.	715	26·75	0·262	74° 50′	87	·0318
II.	405	20·1	0·348	69° 40′	100	·086
III.	171·6	13·1	0·535	57° 40′	107	·334
IV.	482	21·95	0·319	71° 25′	97	·064
V.	382	19·55	0·358	69°	100	·094
						·610



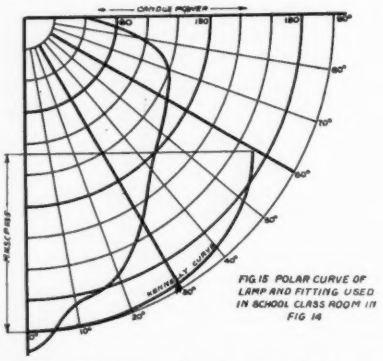


FIG 15 POLAR CURVE OF LAMP AND FITTING USED IN SCHOOL CLASS ROOM IN FIG 14

and as the observed values tended to be less than the calculated values, the utilisation factor has a maximum value of

$$\frac{37}{62} \text{ or } 60\%$$

The low value is largely due to loss through windows of relatively great area.

(6) *Local Lighting by Incandescent Gas over a Workshop Bench.*

With local intensive illumination at specified points, the point by point method of calculation is the only one suitable. Its application is shown in a case of high illumination by inverted gas burners over a workshop bench. Fig. 16 shows the spacing, and plan of bench, together with calculated and observed

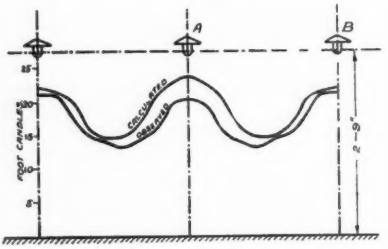


FIG 16 ILLUMINATION OF WORKSHOP BENCH

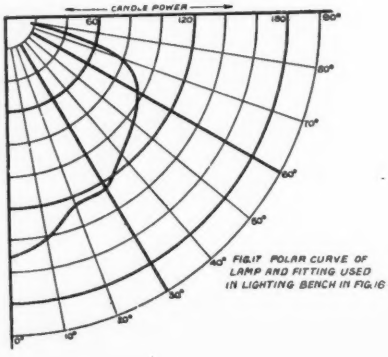


FIG 17 POLAR CURVE OF LAMP AND FITTING USED IN LIGHTING BENCH IN FIG 16

curves of illumination. The figures are given in Table X. and the polar curve in Fig. 17.

The difference between the means of these two sets of values is less than 5 per cent. Reflection from the walls has very little to do with the result, nor has reflection from the dark bench in intensifying the light from the reflectors, although both of these effects may perhaps be masked by small differences in condition between the mantles used over the bench and those employed in getting the polar curve.

In another case of bench and lathe lighting by inverted mantle gas burners, shown in Fig. 18 and Table XI., the observations of illumination were taken under service conditions, with machinery running and people at work. Over bench A the agreement between calculations made from the polar curves shown in Figs. 19 and 20 and observation is good; over benches B and C it is fair,

TABLE X.

Summary and Comparison of Illumination Values. Fig. 16.

Lamp.	Positions.									
	1	2	3	4	5	6	7	8	9	10
A.	2·0	1·48	1·07	0·851	0·667	0·537	0·443	0·363	0·305	0·247
B.	19·85	18·6	16·5	11·2	8·35	5·95	4·42	3·21	2·43	1·855
C.	1·855	2·43	3·21	4·42	5·95	8·35	11·2	16·5	18·6	19·85
Total calctd.	23·7	22·5	20·8	16·5	15·0	14·8	16·1	20·1	21·3	21·9
Observed	20·3	19·6	15·9	14·2	13·2	14·2	15·1	18·0	21·0	21·0

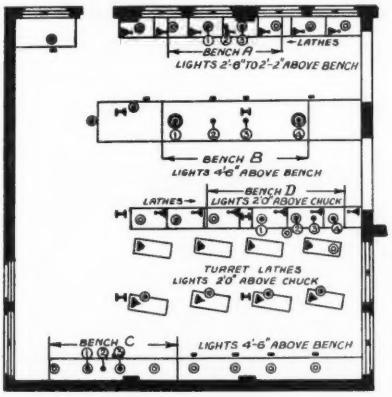


FIG. 18. PLAN OF LIGHTING OF ENGINEERS' SHOP.
POINTS OF OBSERVATION
LIGHTING UNITS WITH POLAR CURVE OF FIG. 19
" " " " " FIG. 20

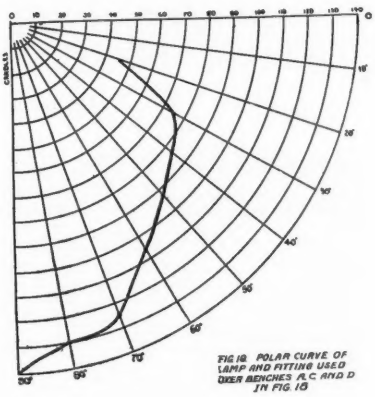


FIG. 19. POLAR CURVE OF LAMP AND FITTING USED OVER BENCHES A, C AND D IN FIG. 18

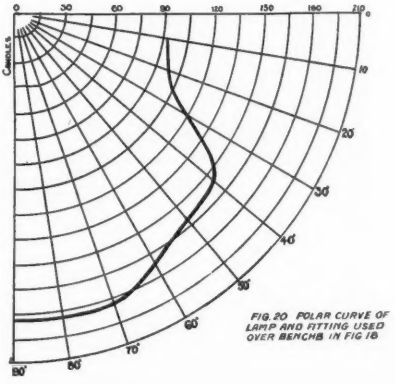
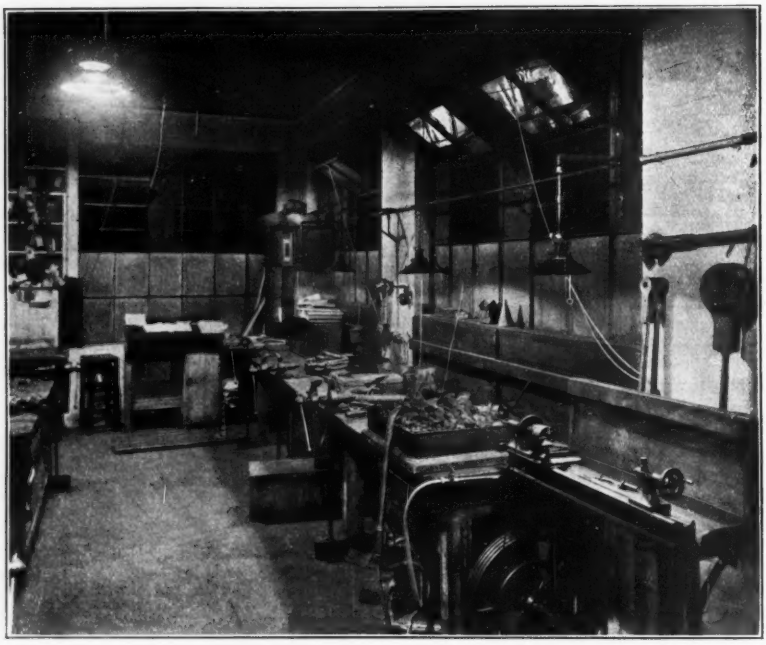


FIG. 20. POLAR CURVE OF LAMP AND FITTING USED OVER BENCH B IN FIG. 18

V.—School Room lighted by low pressure incandescent gas (direct lighting).



VI.—Workshop lighted by incandescent gas (low pressure).

and over bench D it is bad, due to mantles being out of condition. Bench D should get practically constant illumination of a high value if mantles were in good order.

TABLE XI.

Comparison of values in workshop illumination. Fig. 18.

Illumination in ft.-candles.	Calculated	Observed.
Position 1	25·7	30
Bench A. ,, 2	14·0	15
Polar curve ,, 3	33·46	35
Fig. 19		
Position 1	9·2	8·75
Bench B. ,, 2	3·54	4·5
Polar curve ,, 3	2·68	1·75
Fig. 20 ,, 4	9·2	8·0
Position 1	16·6	20
Bench C. ,, 2	16·9	11·5
Polar curve ,, 3	16·9	14
Fig. 19		
Position 1	24·56	8
Bench D. ,, 2	26·66	10
Polar curve ,, 3	22·06	7
Fig. 19		

(7) *Indirect Lighting in a Motor-car Showroom.*

Fig. 21 gives the ceiling plan of a motor showroom on a ground floor showing the position of lighting points for the indirect illumination of the floor 13 feet below it. There are windows opening on to the street on two sides, and extending right up to the ceiling, while on the other two sides of the room there is a dark oak panelled dado to a height of 7½ feet from the floor, the other 5½ feet being a cream-coloured frieze for one side and nearly all window glass to an inner office on the other.

An approximation to the horizontal illumination can be made as follows :—

Each unit consists of four 60-watt tungsten lamps mutually at right angles and placed horizontally within a bowl lined with ribbed mirror glass. Their depth within the bowl is such that no part of the lamp projects above the horizontal plane of the top of the bowl.

Assuming 0·65 mean spherical candles per watt and 240 watts per bowl, the mean spherical candle-power per bowl is

$$0{\cdot}65 \times 240 = 156.$$

Eighty per cent. is given as the co-efficient of reflection of the mirrors, and assuming that two-thirds of the total light is thus reflected, the effective mean spherical candle-power is

$$\frac{156}{3} + 0{\cdot}8 \times \frac{2}{3} 156 = 135.$$

Assume that the polar surface is spherical —an assumption very nearly correct for tungsten filament as usually mounted in a clear globe—then the candle-power in any direction from the vertical is given by

$$I_\theta = I_{max} \cos \theta$$

Hence the flux emitted in this cone centred on the vertical will be—

$$L_\theta = (\text{total flux}) \sin^2 \theta$$

The total flux per unit in this case is

$$4\pi \times 135 = 1700 \text{ lumens—}$$

that is,

$$L_\theta = 1700 \sin^2 \theta$$

The lamps are approximately 2½ feet below the ceiling The flux on to the ceiling from each lamp was calculated from the above relation by taking the largest uninterrupted cone with its base on the ceiling which could be drawn centred about each lamp, finding the flux in this cone, and then dividing the small difference between this and the total flux roughly in the proportion of the aspect of the lamp to the windows and the ceiling. The portion going to the windows is reckoned as lost light, and reflection from floor back to ceiling is neglected.

Thus for Lamp I. the flux within a complete cone having a base of 5 feet radius on the ceiling is given by

$$1700 \times \frac{25}{31{\cdot}25} = 1360$$

leaving only the small difference, 1700 —1360=340 to be divided between the ceiling, the window, and the frieze. The division is taken as being, ¼ direct to

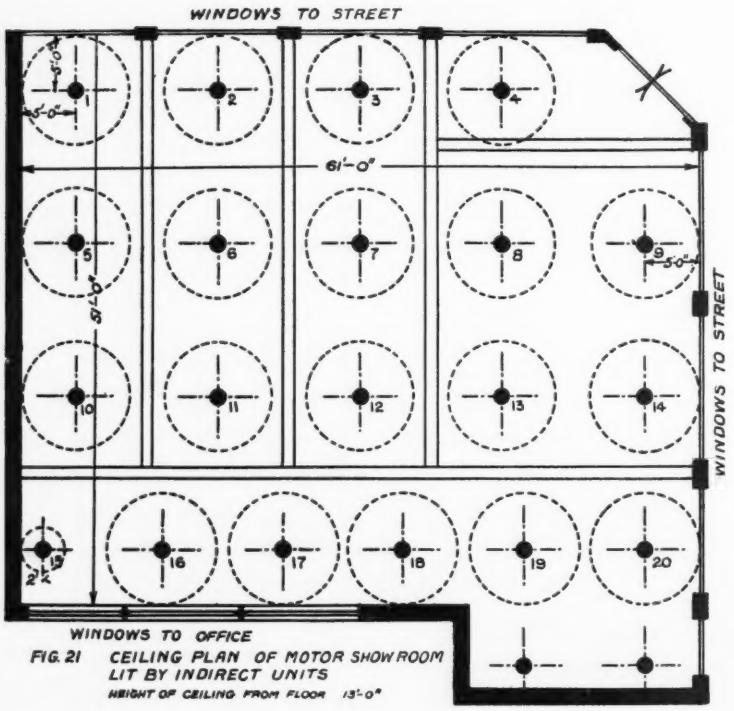


FIG. 21 CEILING PLAN OF MOTOR SHOW ROOM LIT BY INDIRECT UNITS

HEIGHT OF CEILING FROM FLOOR 13'-0"

ceiling, $\frac{3}{8}$ out of the window, and $\frac{3}{8}$ on the frieze. Taking L. Bloch's value for the reflection coefficient of the frieze, 66½ per cent., and allowing that half of the light reflected from the frieze gets back to the ceiling, the rest going to the floor, the total flux on to ceiling from Lamp I. amounts to

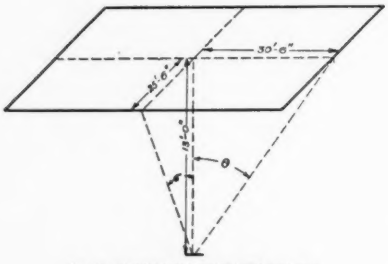


FIG. 22 DIAGRAM TO ILLUSTRATE FORMULA FOR LUMINOUS RECTANGLE

1360+85+42=1487 lumens.

The rest of the twenty lamps in the rectangle have been treated in the same way, resulting in the following table :—

TABLE XII.

Summation of Flux Values. Fig. 21.

Numbers of amps in Fig. 21.	Flux on to ceiling per lamp.	Total flux on to ceiling.
1	1,487	1,487
2, 3, 4, 9, 14, 16, 17, 20	1,530	12,240
5, 10, 19, 18	1,587	6,348
6, 7, 8, 11, 12, 13	1,700	10,200
15	1,090	1,090
Flux reflected from frieze on to floor		440
Total flux		31,805

The total flux on ceiling is therefore 31800 lumens. Area of ceiling is approximately $61 \times 51 = 3110$ sq. ft. Using the same figure for coefficient of reflection from ceiling, 66·5 per cent. the reflected flux per square foot is

$$\frac{31800}{3110} \times \frac{2}{3} = 6{\cdot}68.$$

The formula given by Bassett Jones * for the illumination produced under the centre of a uniformly luminous rectangle is

$$E = \frac{2E^1}{\pi} (\sin\sigma \tan^{-1} \sin\theta + \sin\theta \tan^{-1} \sin\sigma)$$

On substituting these

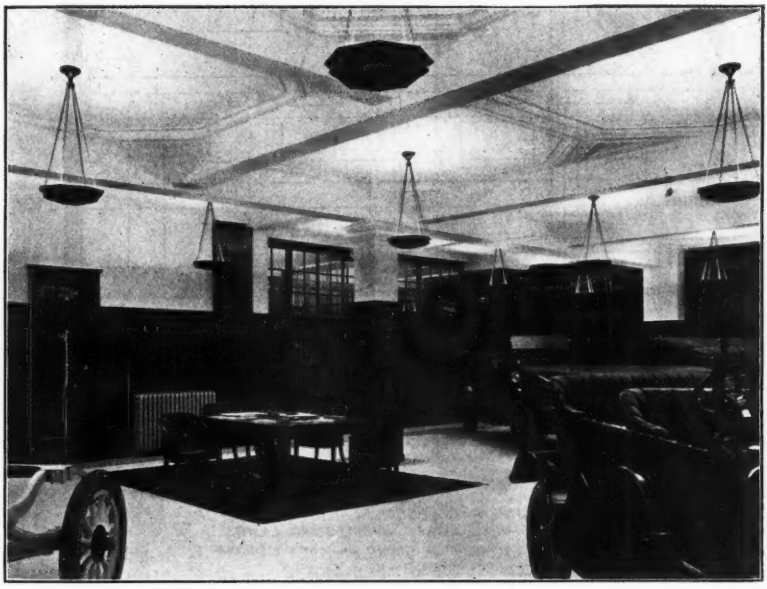
$$E = \frac{2 \times 6{\cdot}68}{\pi} (0{\cdot}892 \times 0{\cdot}743 + 0{\cdot}918 \times 0{\cdot}727)$$

$= 5{\cdot}65$ foot-candles

The observed value was 5·5 foot-candles in the centre of the room.

It was found that the height of the reference plane did not affect the observed values very much, and this is borne out by calculation, for if the reference plane is taken 10 feet below ceiling instead of 13 feet, the values are :—

$\sin\sigma = 0{\cdot}932$ $\sin\theta = 0{\cdot}95$
$\tan^{-1} \sin\sigma = 0{\cdot}75$ $\tan^{-1} \sin\theta = 0{\cdot}759$



VII.—Indirect (tungsten lamp) lighting in a Motor Car Showroom.

where E=horizontal illumination produced underneath the centre of a horizontal uniformly luminous rectangle emitting an illuminaion of E^1 foot-candles, and σ and θ are the angles shown in Fig. 22.

For the case considered the values are :—

$\sin\sigma = 0{\cdot}892$ $\sin\theta = 0{\cdot}918$
$\tan^{-1} \sin\sigma = 0{\cdot}727$. $\tan^{-1} \sin\theta = 0{\cdot}743$.

These values give

$$E = \frac{2 \times 6{\cdot}68}{\pi} (0{\cdot}932 \times 0\,759 + 0{\cdot}95 \times 0{\cdot}75)$$

$= 6{\cdot}03$ foot-candles.

The depth from ceiling to reference plane has been altered 23 per cent. The alteration in the illumination is only 6·75 per cent., whereas if the source of illumination had been a point, and the same percentage diminution had been made in the distance of the point illuminated, the increase in the illumination would have been 69 per cent.

* Bassett Jones, *Proc. Am. Illum. Eng. Soc.*, 1909, Vol. IV., p. 230.

(8) *Lighting of Room for Manual Training by inverted arc lamps.*

The room is 39 feet by 32 feet, and is 12 feet high to the flat portion of the ceiling, which is intersected by two main beams 15 inches deep and 19 inches wide, parallel to one another as shown by the fine dotted lines in Fig. 23. There are cross beams, but these are much shallower. The lighting is effected by four inverted arc lamps fixed on the main beams and 25 inches below them, at the centres shown. The walls are faced with a dark brown glazed brick reaching to the ceiling. Practically all the light above an average of 15° from the horizontal goes on to the ceiling. Allowing for this, the projection of the Kennelly curve in Fig. 24 gives

$815 \times 2\pi = 5120$ lumens as the flux per lamp thrown on to ceiling.

With four lamps, total flux to ceiling =

$$4 \times 5120 = 20480 \text{ lumens.}$$

The ceiling has been distempered a light colour, but is now rather dirty, the surface being about two years old at the time the photometric tests were taken.

Assuming the coefficient already used for clean ceilings, the total flux from ceiling would have been

$$20480 \times \tfrac{2}{3} = 13650 \text{ lumens.}$$

In view of Clewell's curves of deterioration (Fig. 13), it would be reasonable to assume in this case a further loss of 25 per cent. of the light. The average flux density leaving the ceiling is then

$$\frac{13650 \times 3}{4 \times 39 \times 32} = 8{\cdot}2 \text{ foot-candles.}$$

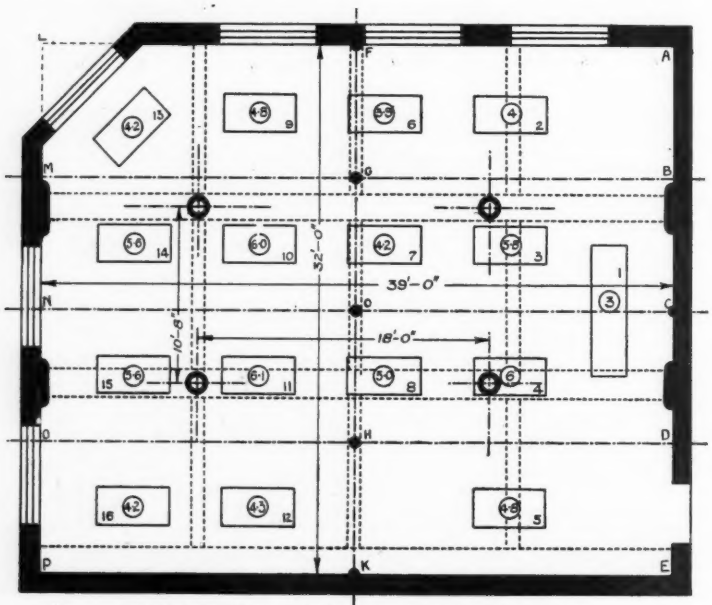


FIG. 23 CEILING AND FLOOR PLAN OF ROOM FOR MANUAL TRAINING LIT BY INVERTED ARC LAMPS
FOOT CANDLES ILLUMINATION ON BENCHES GIVEN WITHIN CIRCLES

The working benches are 2 feet 9 inches from the floor. Assuming the ceiling to be a flat rectangle, the illumination immediately underneath its centre and at a depth of 9 feet 3 inches is given as

$$E = \frac{2 \times 8{\cdot}2}{\pi}(\sin\theta \tan^{-1}\sin\sigma + \sin\sigma \tan^{-1}\sin\theta)$$

where $\sin\theta = 0{\cdot}90$ $\sin\sigma = 0{\cdot}865$

$\tan^{-1}\sin\theta = 0{\cdot}733$ $\tan^{-1}\sin\sigma = 0{\cdot}714$

substituting these values, the illumination is

$$\frac{16{\cdot}4}{\pi}\ (0{\cdot}643 + 0{\cdot}635) = 6{\cdot}7 \text{ foot-candles.}$$

The actual readings obtained are shown within the circles drawn on the benches in Fig. 23. The mean of the observed values at the four positions nearest to no allowance has been made for the presence of the beams. The presence of cross reflections from the vertical sides of one beam to the other would tend to reduce the effective reflective co-efficient of the ceiling as a whole. The engineers responsible for the lay-out of this installation were using certain spacing rules and reflection coefficients which gave them a figure of 7·5 foot-

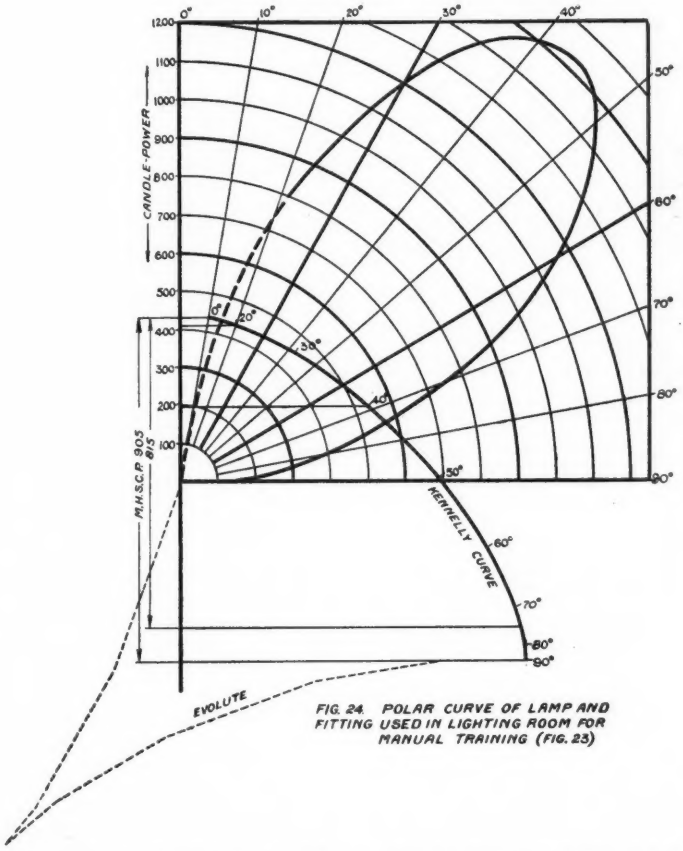


FIG. 24. POLAR CURVE OF LAMP AND FITTING USED IN LIGHTING ROOM FOR MANUAL TRAINING (FIG. 23)

the centre of plane of reference is 5·3 foot-candles, a discrepancy of about 21 per cent. There is no doubt that this is in the main due to a shrinkage in the polar values on service as compared with those obtained in laboratory tests, inevitable with arc lamps. Possibly also a too sanguine view has been taken of the reflective capability of the ceiling, and candles for the mean horizontal illumination as the maximum possible under the best conditions, but their experience of this type of lighting enabled them to quote as a figure for actual service 5·0 foot-candles, which is within 3½ per cent. of the figure found.

The formula for the luminous rectangle can be used to predict the variation of

illumination disclosed by the observations on benches 9, 10, 11, 12, as follows :—

The illumination at O already calculated can be considered as made up of four equal portions due to the four symmetrically situated rectangles into which the whole area can be divided about that point. The illumination immediately underneath the corner O due to the rectangle A C O F must be the same as the illumination due to that rectangle under either of its other three corners. Hence the illumination at F due to area A L N C is 3·35 foot-candles. The total illumination at F is half that due to a rectangle of twice the floor area, with F as centre. This has been calculated, and is 3·64. The further rectangle C E N P only increases the illumination by 3·64—3·35=0·29 foot-candles, or about 9 per cent.

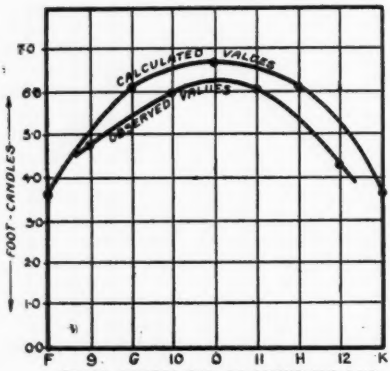


FIG. 25. COMPARISON OF OBSERVED AND CALCULATED VALUES OF ILLUMINATION ALONG THE LINES 9, 10, 11, 12, AND FGOHK IN FIG. 23

In the same way the illumination at G has been calculated as the sum of that due to the rectangle A B L M, and the rectangle B E P M, and found to be 2·61+3·56=6·17 foot-candles. The calculated variation of illumination along the line F G H K and the observed variation are compared together in the curves of Fig. 25.

The diversity coefficient determined by the ratio of the maximum observed value at position 11 to the minimum observed value at position 1 is

$$\frac{6{\cdot}1}{3{\cdot}0}=2{\cdot}03$$

which is in very good agreement with the ratio of 2·00 between the calculated value at O and that at C or F.

In calculating the illumination underneath either the centre or the corners of a uniformly luminous rectangle, which is nearly square, no serious error is introduced if the simplified formula for a square of the same area is used.

The formula reduces to

$$E=\frac{4E^1}{\pi}\sin\theta\tan^{-1}\sin\theta$$

Thus in the case considered, E would be given as :—

$$\frac{4\times 8{\cdot}2}{\pi}\times 0{\cdot}886\times 0{\cdot}724=6{\cdot}69 \text{ foot-candles,}$$

or the still more easily remembered rule for the luminous disc might be used,

$$E=E^1\sin^2\theta$$

which gives in this case for a circle of equal area

$$E=8{\cdot}2\times 0{\cdot}822=6{\cdot}75 \text{ foot-candles.}$$

(9) *The Direct Lighting of a large Machine Shop by Flame Arc Lamps.*

With the exception of one or two isolated instances, all the installations hitherto dealt with have been of such a kind that it has been possible to make photometric tests under nearly laboratory conditions ; that is to say, the light sources and their surroundings were giving very approximately, one the laboratory polar curve and the other laboratory values of coefficients of reflection and diffusion. In this concluding example, the difficulties that arise when dealing with the lighting of a large floor area encumbered with heavy machinery driven by a maze of belting from overhead shafting will be made apparent.

The shop in question is 280 feet long by 240 feet wide, with a saw-tooth roof over nine bays, and is lit by 36 flame arc lamps spaced as shown in Fig. 26. There is a rail track up the centre of each bay, with machine tools along each side driven from overhead shafting. Owing to the requirements of the work, the lamps had to be put 5 feet above the eaves, which are 20 feet from the floor, giving 21 feet from the arc point to a plane of reference 4 feet high. The object was to secure on this plane as uniform an illumination as possible,

having regard to the large amount of obstruction.

The polar curve of the lamp and fitting used is given in Fig. 27, and from this the mean hemispherical candle-power is 3,680. The total light flux per point available under the best possible conditions is

$$3680 \times 2\pi = 23100 \text{ lumens.}$$

The approximate estimate of the mean horizontal illumination, taking these facts into consideration, can be deduced from the figures in Table XIII., which gives the flux per lamp for the lamps numbered 1 to 10, estimated from the effective zones and portions of zones shown for two lamps in Fig. 26.

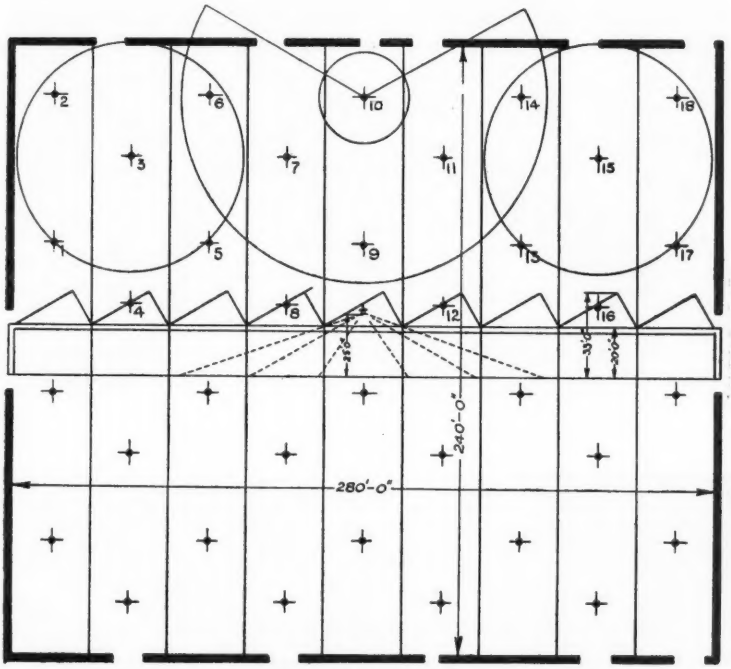


FIG. 26 PLAN AND ELEVATION OF ENGINEERS' SHOP DIRECTLY LIT BY FLAME ARC LAMPS

The floor area is 67,200 square feet, so that if it were cleared of all obstructions, and all the light from the 36 lamps had been directed on to it, the mean horizontal illumination would have been

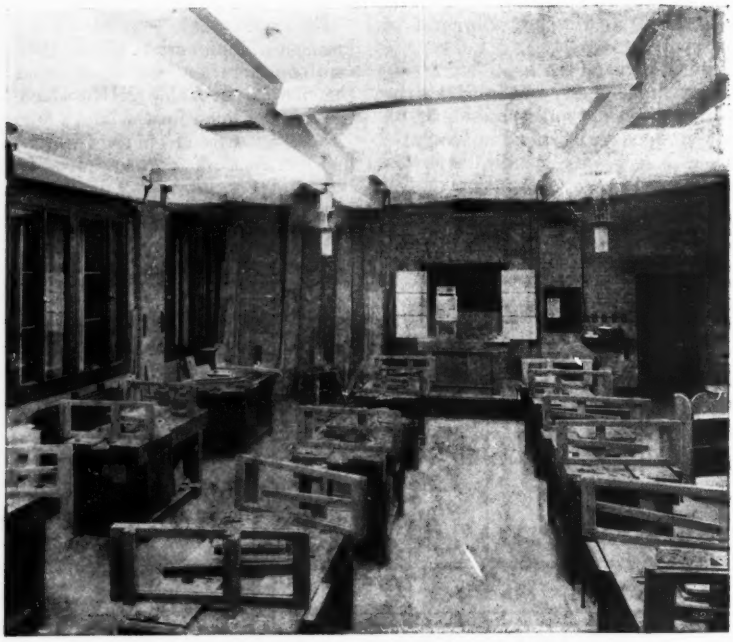
$$\frac{23100 \times 36}{67200} = 12{\cdot}4 \text{ foot-candles.}$$

From the height at which the lamps are mounted in the roof it is clear that a considerable amount of light could never reach the floor; also the light that falls on the walls can be taken as practically lost, at any rate as far as the major portion of the area is concerned.

TABLE XIII.

Number of lamps.	Total flux to reference plane in lumens.	Number of lamp.	Total flux to reference plane in lumens.
1	12200	6	12200
2	8925	7	15680
3	14210	8	16990
4	15820	9	16790
5	16740	10	12200

Lamps 1 to 8 are symmetrical about the short centre line of the shop with lamps 11 to 18, and as the lamps in every other bay are symmetrical about



VIII.—Workshop lighted by indirect arc lamps.

IX.—Workshop lighted direct by flame arc lamps

the long centre line, it can be taken with sufficient approximation that the flux over one half of the floor is the same as that over the other.

The total flux is, therefore,

4 (flux from lamps 1 to 8) + 2 (flux from lamps 9 and 10) = $4 \times 113{,}365 + 2 \times 28990$
= 511,400 lumens,

and mean horizontal illumination over a clear and empty space would be

$$\frac{511400}{67200} = 7{\cdot}6 \text{ foot-candles.}$$

Actually, when readings were taken nearly two years after the lamps were installed, with practically all the machinery and belting in position and running, the mean horizontal illumination was found to be 2·6 foot-candles, and the minimum, in direct view of the lamps, was 2·4 foot-candles. This mean value is well above that demanded, while the chief object aimed at, the attainment of uniformity, is also secured.

It is instructive to note that in the lighting of shops of this kind, full of heavy machinery, and with a lot of top hamper, only about one-third of the light directed towards the floor actually gets there.

The cases dealt with have each been typical of their kind, and were selected for that reason from amongst a large number available. Although their discussion has not elicited anything new or original I hope that it may have helped to remove any doubt remaining of the proposition that light for illumination purposes is capable of estimation and measurement, on an engineering basis.

My thanks are due to those firms and individuals who have been public-spirited enough to allow of the publication of data secured at great cost to themselves. I wish particularly to mention the assistance received from the following gentlemen:—

Mr. J. G. Clark, Mr. G. Herbert, Mr. V. H. Mackinney, Mr. F. Maurice, Mr. T. E. Ritchie, Mr. H. Staniforth, Mr. F. W. Willcox, and Mr. H. C. Wheat.

I am also glad to acknowledge my great indebtedness to Mr. J. S. Dow for the very generous help he has afforded. Without either the one or the other, this paper could not have been written.

[*The complete account of the Discussion of this paper, together with Mr. Clinton's reply, will be published in our next number.*—ED.]

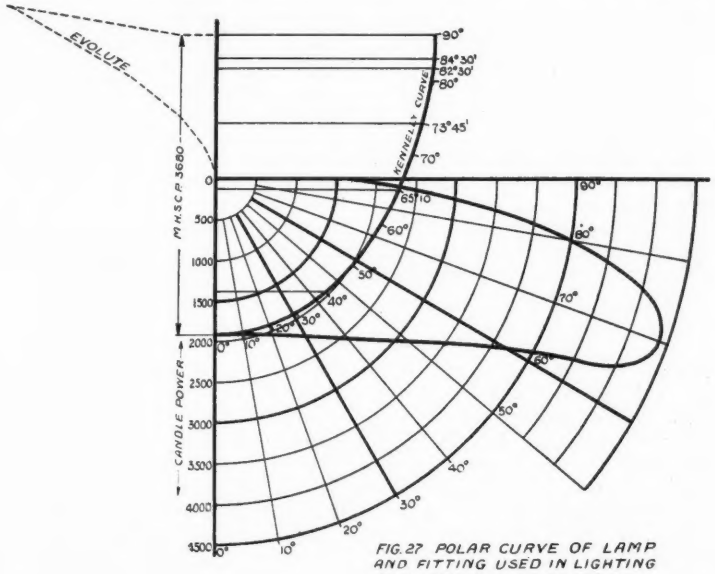


FIG. 27. POLAR CURVE OF LAMP AND FITTING USED IN LIGHTING ENGINEERS' SHOP OF FIG. 26

ILLUMINATION AND THE TEXTILE INDUSTRY.

In a lecture before the Society of Dyers and Colourists at The Dyers' Hall, on March 26th, a paper on the above subject was read by Mr. Léon Gaster.

Mr. Gaster pointed out the vastness of the great textile industry, and the important part played in many textile operations by illumination. He referred to the valuable information on the illumination in various mills collected by Mr. D. R. Wilson and published in the Report of H.M. Chief Inspector of Factories for 1911, and to several recent papers before the National Gas Congress last year. Amongst these was a paper by Mr. T. Franklin Thorp, of Manchester. Mr. Thorp had had opportunities of satisfying himself that the economic value of good lighting was becoming thoroughly recognised by progressive manufacturers as well as the workpeople, many of whom were paid by piece work.

Mr. Gaster proceeded to illustrate by lantern slides how lamps are usually placed in the spinning alleys, how they should be shielded from the eyes of the workers, and how important it was to secure ample illumination on the looms and the intricate machinery used in textile mills. He himself had noticed cases in which a man attended to two adjacent identical machines, one of which was adequately lighted by a well-shaded lamp and the other by a bare lamp of the same candle-power but giving a glaring effect. The operators all agreed that they could not get nearly such good results from the machine using the unscreened lamp in the range of vision as from the other where the lamp was shaded. The expenditure of energy was the same in both cases, but the illumination on the work was more than double when the shade was used.

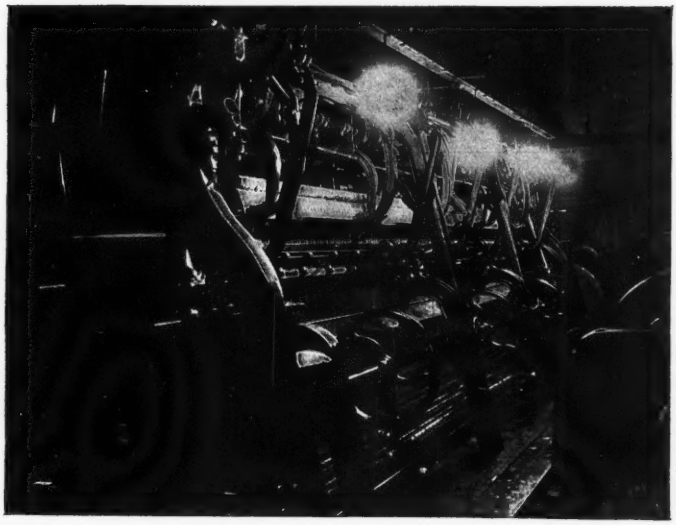
Passing on, Mr. Gaster emphasised the importance of good illumination in the dyeing and bleaching industries, and other trades where coloured fabrics are worked. He pointed out that it was only fair to the operator in a factory that the illumination on the spot where he prepared the material should be quite as good as at the place where it was subsequently inspected.

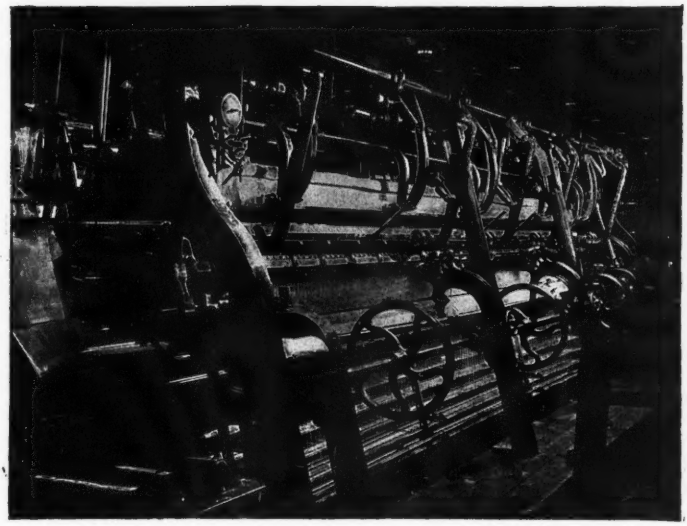
Another important point in such industries was the colour value of the illuminants used. It was well known that some illuminants differed from daylight, and distorted the colours of objects, much more than others. And there had also been attempts to produce what was called "artificial daylight," *i.e.* lamps provided with special tinted screens which altered the colour constitution of the rays in such a manner as to bring about a close resemblance to daylight. Another recent advance in this direction was the Moore (carbon dioxide) tube, which was now made in compact small units very suitable for colour-matching.

It was admittedly difficult to imitate daylight exactly in this way; but daylight was in itself a very variable commodity according to the climatic conditions. For example, on dull and foggy days many colour-matching operations could not easily be undertaken, and in cities particularly such sombre conditions might come about without warning. Now artificial daylight, even if not identical with daylight, was at least moderately constant in operation.

In conclusion, Mr. Gaster pointed out that there were many industries in which it was not necessary to be able to match all the most delicate shades exactly, but only a somewhat limited range of colours. For example, the grading of hops, tobacco, flour, and even biscuits was done to a great extent by colour; but in the main only reddish, yellowish, and brownish tints were involved, and not the delicate greens and blues which were so often a difficulty. For such work as this an illuminant which came moderately near to daylight might be distinctly serviceable.

The lecture was illustrated by a number of lantern slides, cabinets containing incandescent "daylight" lamps, and examples of arc lamps for colour-





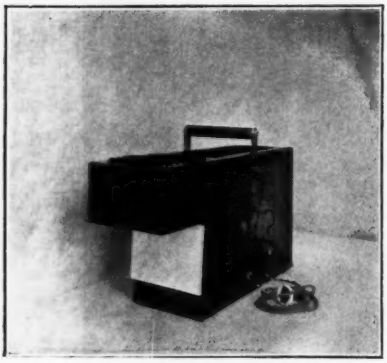
AN EXAMPLE OF BAD LIGHTING IN A SPINNING MILL AND HOW IT WAS CORRECTED.

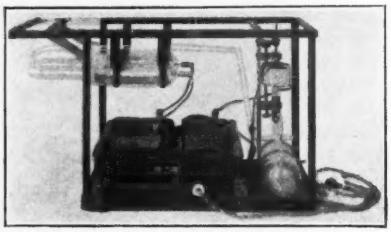
These two photographs show the difference between good and bad illumination. In the top picture five 64-watt carbon lamps, equipped with ordinary enamelled iron shades, are used. In the second photograph, six 40-watt electric lamps with steel reflectors give a very much improved illumination. Not only is there a saving of 80 watts but the illumination lights the bottom of the loom and obviates the necessity of bringing down the batten of lights whenever a thread breaks (as had to be done with the old lighting). Note the absence of irritating glare in the lower picture.

(From *Industrial Lighting.*)

matching. Mr. Gaster also exhibited a picture (shown by Mr. Eck at a meeting of the Illuminating Engineering Society in 1912), half of which was painted by daylight and half by the light of the inverted arc. Without the aid of the "key" provided no one could tell which was which.

The lecturer pointed out that in many chemical and dyeing works perfect cleanliness was most essential both to the success of the processes that went on and also to the welfare of the operators. Now such cleanliness was only possible when the lighting was satisfactory. Poor illumination was not only a menace to the health of the workpeople but a very bad investment to the employers. It was also suspected, with good reason, of causing preventible accidents. In short, good illumination is "everybody's business."





New Compact Moore Light for Colour-Matching.

Weight, 35 lbs. Dimensions, 21″×7″×12″
Watts, 330. Illumination, 100 ft.-candles (immediately under lamp).

MUNICIPAL GAS AND ELECTRICITY UNDERTAKINGS SHOULD WORK TOGETHER.

At the 44th Annual Meeting of the Manchester District Institution of Gas Engineers an address was delivered by Mr. J. G. Newbigging, in the course of which he pointed out the great opportunities for co-operation between the gas and electricity departments in cases where both are run by municipal authority. We take from the *Journal of Gas Lighting* the following summary of a portion of his remarks on this occasion :—

"The general public is totally indifferent as to which undertaking is supreme—all they require is that they shall receive sound and impartial advice as to which is best suited to their particular requirements; and no one can deny that there are numerous instances where this help is essential. The position to-day is that such advice is not available, because the business of both undertakings is conducted as though they had not the remotest connection with one another, when they are in fact two departments of the same firm, in the shape of the corporation, borough council, or urban authority, as the case may be. The result is that they are left to their own devices to push business as best they can, irrespective of the injury they may inflict on each other, which oftener than not recoils on their own undertaking. . . .

"The obvious remedy for all this was that the general administration and policy of the two departments should be merged into one, to be called the light, heat and power department, under the supreme control of one committee, which would, if it were composed of broad-minded and common-sense men, conduct the business in the interests of the consumers, irrespective of the ascendancy of the one commodity over the other."

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

ONE of the most interesting issues of the last month is the March *General Electric Review*, which contains a number of articles on illumination. There are three sections devoted respectively to Light, Lamps and Illumination, apart from other matter dealing with distribution problems. **Street lighting** receive special attention. Dr. BELL comments on the increasing use of small units at frequent intervals, and the future of the half-watt lamp.

W. C. ALLEN describes a highly decorative street lighting installation comprising massive diffusing globes on pillars, and W. D'A. RYAN contributes a fully illustrated article on **spectacular lighting,** containing night photographs showing the illumination of the Niagara Falls, the Singer tower and other well-known effects.

A recent issue of the *Journal of Electricity, Power and Gas* (February 21st) raises a distinctly new point—the practicability of indirect lighting out of doors. Naturally in such cases some form of artificial "ceiling" must be provided, *e.g.*, either there must be an extended light surface above the lamp or use must be made of the exteriors of buildings. It appears that this principle is to be extensively used in the coming San Francisco Exposition, in the form of illuminated banners, &c.

While referring to spectacular lighting reference should be made to the interesting article by STUMCKE (*E.T.Z.*, Jan. 29th) tracing the historical development of **stage lighting** in Germany from the old days when candles were employed. Reference is made to the comments of Lavoisier and other enlightened savants all of whom agreed as to the cardinal principle of screening the lights from the spectators and directing the rays on the stage; yet it appears that in the early days of theatre lighting this practice was by no means universally followed.

W. VOEGE (*E.T.Z.*, Feb. 19th) describes a series of tests on the "**Marmorlicht.**" He gives the results of detailed experiments on appliances made of marble, and contends that the absorption of this material is considerably less than can be secured by the use of ordinary white glass.

Turning to more scientific articles we may note TEICHMULLER'S contribution on the nomenclature of illumination and the flux of light (*J.f.G.*, Feb. 28th) and the articles by ROLPH and JACKSON on the applications of spacing rules in practical lighting installations. "S." (*J.G.L.*, Feb. 21st) endeavours to show that the majority of problems can be solved by the use of several comparatively simple formulæ.

NORDEN, in a recent paper before the German Illuminating Engineering Society again discusses the best methods of expressing **diffusion of light** and shadow in numerical terms (*Z.f.B.*, Feb. 28th).

ELECTRIC LIGHTING.

Here again reference may be made to the March issue of the *General Electric Review*, where there are a number of articles bearing on the half-watt lamp.

MONGINI (*Z.f.B.*, Feb. 20th) gives the results of some tests on lamps run on A.C. and D.C. circuits, some at normal voltage, others overrun. It appears that no distinct difference can be noted in the behaviour in the two cases.

GREINACHER (*E.T.Z.*, March 5th) describes a new form of glow lamp depending on a spark-discharge between platinum electrodes. It appears that with about 500 volts quite a considerable candle-power can be obtained in this

way. For example, one lamp consuming 90 watts gave about 50 candle-power. The author thinks it is possible that by using potassium electrodes in helium gas as low a voltage as 100 might be used.

CLAUDE (*Z.f.B.*, Feb. 20th) gives some further particulars of the Neon tube. It is claimed that under the best conditions 0·5 watts per h.k. can be obtained. The author also describes the use of a subsidiary tube containing mercury so that the combination of the two lights will give an approximately white light.

GAS, OIL, ACETYLENE LIGHTING, &c.

BODE in a recent paper before the German Illuminating Engineering Society traces the development of the incandescent gas light and C. KILLING (*J.f.G.*, Feb. 10th) describes in detail a new form of inverted burner lamp which is said to give very efficient results. According to the figures quoted about 0·7 litres per Hefner (approx. 32 c.p. per cub. ft.) is claimed.

Apart from a very fully illustrated article by F. H. GILPIN on automatic and **distance lighters** (*Am. Gaslight Jour.*, Feb. 23rd) the chief item of interest in American papers is the Report of the Committee of the Gas Institute on Indoor Lighting (*ibid.*, March 9th). This contains a great many sound recommendations to gas canvassers, the illumination data for various lamps being compressed into a small space and issued in a readily intelligible form. Special reference is made to the value to canvassers of photographs of lighting installations.

Finally, we may note the editorial in the *Journal of Gaslighting* in which it is suggested that the present transition period, when both a calorific and an illuminating test are imposed, might now come to an end and that only a calorific test should be used in future.

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Glinski, H. V. Rechnerische Ermittlung der sparsamsten Beleuchtung für einen gegebenen Lichtbedarf (*E. T. Z.*, Jan. 29th).

Jackson, J. G. Planning Light Installations (*Jour. of Electricity, Power and Gas*, Feb. 21st).

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Teichmuller, J. Beleuchtung und Lichtstromdichte (*J. f. G.*, Feb. 28th).

Voege, W. Das Marmorlicht (*E. T. Z.*, Feb. 19th).

Way, S. B. Elements of a Streetlighting Contract (*Elec. Rev. and Western Electrician*, Feb. 21st).
New Lighting System on the Pennsylvania Avenue (*Elec. World*, Feb. 28th).
Outdoor Indirect Lighting (*Jour. of Electricity, Power and Gas*, Feb. 21st).
Glanz und Blendung (*L. u. L.*, Feb. 12th).
The Method of Flicker in Heterochromatic Photometry (*Elec. Rev. and Western Electrician*, Feb. 21st).

The *General Electric Review* (New York) for March is a special lighting number and contains the following articles on *Light* (Section I.) and *Illumination* (Section IV.):—

Light (Section I.):—
Light (W. R. Whitney)—The Problem of Light Production (E. P. Hyde)—Efficiency of Illuminants (C. P. Steinmetz)—Modern Theories of Light (S. Dushman)—The Spectroscope (Elihu Thomson).

Illumination (Section IV.):—
Present Tendencies in Streetlighting (L. Bell)—A Notable Development in Ornamental Street Lighting (W. C. Allen)—A Modern Arc Lighting System (G. N. Chamberlain)—Some Special Fields of Incandescent Lighting (G. H. Stickney)—Interior Illumination (A. L. Powell)—Illumination and Art (M. Luckiesh)—Spectacular Illumination (W. D'A. Ryan).

Electric Lighting.

Claude, G. Beleuchtung mit Neonröhren (*Z. f. B.*, Feb. 20th).
Greinacher, H. Ueber eine neue Glühlampe (*E. T. Z.*, March 5th).
Mongini, G. Untersuchungen an Metallfadenlampen (*Z. f. B.*, Feb. 20th).
Die Entwicklung der elektrischen Strassenbeleuchtung (*J. G. L.*, March 14th).

The *General Electric Review* (New York) for March contains the following articles on *Lamps* (Section III.) :—

Lamps (*Section III.*) :—

The Immediate Future of the Half-Watt Lamp (L. A. Hawkins)—The Quartz Mercury Lamp (E. Weintraub)—The Manufacture of Drawn Wire Tungsten Lamps (J. W. Howell)—Characteristics of Mazda Lamps (E. J. Edwards)—Influence of Research on the Manufacture of Incandescent Lamps (J. E. Randall)—Field of the Gas-filled Mazda Lamp (S. H. Blake)—Improvements in the Magnetite Arc (C. A. B. Halvorsen)—The Flicker of Incandescent Lamps on A.C. Circuits and Stroboscopic Effects (I. Langmuir).

Gas, Oil, Acetylene Lighting, &c.

Bode. Entwicklung des Gasglühlichtes (*Z. f. B.*, Feb. 28th ; *L. u. L.*, Jan. 29th).
Editorial. The Future of the Lighting Trade (*G. W.*, March 7th).
The Calorific Standard (*J. G. L.*, Feb. 10th).
Gilpin, F. J. Automatic and Distance Gaslighters (*Am. Gaslight Jour.*, Feb. 23rd).
Haber, F. Rare Earths and Gaslighting (*J. G. L.*, Feb. 10th).
Killing, C. Ueber eine neue sehr ökonomische Gasglühlicht-Hängelampe (*J. f. G.*, March 7th).
Report of the Committee on Indoor Lighting (*Am. Gaslight Jour.*, March 9th).
High Pressure Lighting in Manchester (*G. W.*, March 7th).

CONTRACTIONS USED

E. T. Z.—*Elektrotechnische Zeitschrift.*
J. f. G.—*Journal fur Gasbeleuchtung.*
J. G. L.—*Journal of Gaslighting.*
G. W.—*Gas World.*
L. u. L.—*Licht und Lampe.*
Z. f. B.—*Zeitschrift fur Beleuchtungswesen.*

SHOP LIGHTING by

HALF WATT OSRAMS.

The accompanying illustration, reproduced from a photograph taken entirely by the light of the lamps, shows the excellent distribution of light obtained from Osram Half-watt lamps at Messrs. Harrod's premises, Brompton Road, S.W.

The lamps are fitted in "Equiluxo" glassware spheres.

Full particulars and prices post free on request.

THE
General Electric Co.,
Ltd,
Head Office:
67, Queen Victoria Street,
London, E.C.

VIEW OF ONE OF THE COUNTERS AT MESSRS. HARRODS.

TRADE TOPICS AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

LIGHTING OF A MINIATURE PANORAMA AT AN EXHIBITION.

The above illustration shows an interesting miniature lighting installation undertaken by **The Benjamin Electric Co.** at a London Exhibition.

The scene shows troops assembling in a mountainous district. It is lighted by lamps in Benjamin reflectors, which are concealed above. The installation is made interesting by the fact that the ceiling slopes steeply upwards towards the back of the picture, and the lights there are consequently much higher than those in the foreground. In order to meet this point "E" reflectors are used in the foreground, "I" reflectors in the middle distance, and "F" reflectors at the back. The proper spacing is adopted in each case, and the illumination all over was found to be extremely even.

ROYAL EDISWAN LAMPS, etc.

Our attention is drawn to several items concerning **Ediswan** lamps. We note that the India Office has accepted a tender from the company, and that on one of the Northern Railways a signal lamp (carbon filament) has achieved what appears to be a record by burning for no less than 22,607 hours.

We have also to acknowledge the receipt of the EDISWAN abridged catalogue, which, although curtailed, contains particulars of quite a miscellaneous variety of glassware. We notice that the latest "Half-watt" fittings are included and that the new "Ultralux" white glass reflectors are listed.

ARTIFICIAL DAYLIGHT.

At a meeting of the Society of Dyers and Colourists on March 26th (see p. 216), the lecturer showed a variety of lamps designed to furnish "artificial daylight" and therefore adapted to the needs of trades where accurate colour-matching is attempted. These included cabinets fitted with the Benjamin unit, and the Siemens "Verico" incandescent lamp, and the "Coltru" and other arc lamps exhibited by the Union Electric Co.

INDEX, April, 1914.

		PAGE
Comparison of Estimated and Observed Values of Illumination in some Lighting Installations, A	W. C. CLINTON	189
Editorial	L. GASTER	173
Fatigue, Instrument to Measure		188
Illumination and the Textile Industry	L. GASTER	216

Illuminating Engineering Society—
(Founded in London, 1909.)

Account of Meeting on March 17th	187
New Members	187
Notice of Next Meeting	187
Discussion on Picture Lighting (Feb. 17)	177
International Naval Exhibition (Genoa)	188
Picture Galleries and Art Studios, Lighting of [Mr. V. H. Mackinney—Mr. P. Bigland—Mr. David Murray—Mr. S. E. Thornton —Mr. W. E. Bush—Mr. Justus Eck—Mr. T. E. Ritchie—Mr. J. Darch— Mr. J. S. Dow—Mr. Haydn T. Harrison—Prof. Silvanus P. Thompson.]	177
Review of the Technical Press	219
Royal Institute of Public Health, Annual Congress	188
Trade Topics	222

HOLOPHANE GLOBES ILLUMINATING A PUBLIC STATUE.

THE adjacent illustration shows a statue of Michael Arthur, the first Baron Burton and Lord Mayor of this City. Immediately under the ledge four Holophane globes have been mounted. These serve to illuminate the light surface of the pedestal and the inscription, making the memorial easily visible by night. Each of these globes carries a 100-watt lamp.

Before this artificial illumination was provided the statue was frequently a source of danger on dark and foggy nights, being right in the centre of the road. But it has now become quite a prominent feature in the street, and its presence is readily recognised at a distance.

In a paper recently read before the London Society it was claimed that memorials in our great cities ought to be illuminated, and they should be "memorials by night as well as by day." Here surely we have an illustration in point.

Statue of the first Lord Mayor, Burton-on-Trent. Note the lamps in Holophane globes used to illuminate inscription and base of statue.

ARTISTIC GAS LIGHTING FITTINGS.

AT the half-yearly meeting of the South Metropolitan Gas Co., the Chairman, Dr. C. Carpenter, had something to say on the importance to the industry of artistic gas fittings. We take from the Co-Partnership Journal the following reference to his remarks on this occasion :—

"We were laughed at when we first went into the market for artistic gas fittings. 'Who wants them?' we were asked. Mainly upon our initiative, an enormous business in them has now sprung up, the benefit of which is being felt by other companies as well as by ourselves. But the greatest advance has been by the so-called 'Metro' burner. . . . We have now more than 100,000 of them in use; their rate of adoption being really governed by our ability to keep going with the supply. We have said good-bye to the day when our interest in our consumers finished with giving them a supply of gas at the outlet of their meters. . . . We are continually at work in our laboratories seeking for the best devices to satisfy the consumers' needs, and then, with the manufacturing aids of an open market, ensuring that the appliances are available for everyday life and use. These productions of ours have won praise and approval from the heads of gas undertakings all over the Kingdom; and they have even been echoed from the Continent. Our exhibit at the Ideal Home Exhibition at Olympia last year was a revelation to many as to the possibilities of gas for, above all, pleasing and artistic lighting."

We have always believed that there was an important field for enterprise in this direction and feel sure that Dr. Carpenter's comments will be appreciated by many in the gas industry.

MAZDA LAMPS FOR TEXTILE FACTORIES.

THE two illustrations used on page 217 in this number were taken from *Industrial Lighting*, the well-known booklet issued by the British Thomson-Houston Co. It is stated that the improved illumination in this instance was secured by using Mazda lamps and Mazdalux angle reflectors. The booklet contains photographs of many other B.T.H. installations in textile mills.

In the literature sent us this week by the company we notice particularly some floor and table indirect lighting units, a novel lighting device which is not much known in this country at present, and on which we hope to say something in a coming issue.

IMPROVED LIGHTING IN ST. PANCRAS.

THE St. Pancras Borough Council have already installed a number of 10-ampère Angold magazine arc lamps, giving between 3000 and 4000 c.p., in the Euston Road. This compares with 400 c.p. yielded by the old lamps, so that the illumination has been increased approximately ten times.

Similar lamps have been erected by the St. Pancras Borough Council in the Tottenham Court Road, Hampstead Road and Camden Road.

ELECTRICAL TRADES BENEVOLENT INSTITUTION.

FESTIVAL DINNER, MARCH 25TH.

THE Annual Dinner of the Electrical Trades Benevolent Institution took place on March 25th, Mr. H. Hirst presiding. There was a large gathering and a number of entertaining speeches, one and all endorsing the genuineness of the aims and objects of the Institution. In the course of the evening £2,700 was subscribed to the fund—a result which must have been regarded as a gratifying recognition of the efforts of the officers of the Institution, and especially the genial and hard-working Chairman of the Executive Committee, Mr. Justus Eck.

The President is Sir David Salamons. Under his distinguished patronage the Institution will undoubtedly make substantial progress, and win further well deserved support.

A CORRECTION.—With reference to the work by Mr. Phillip A. Robson on School-Planning, mentioned in our last issue (p. 163), we are asked to state that this contains about one hundred illustrations, and is published by Nicholson-Smith, No. 5, St. Stephen's House, Westminster.

The
ELECTRICITY · ACETYLENE ·
ILLUMINATING ENGINEER
OIL · GAS
Edited by
LEON · GASTER

THE JOURNAL OF SCIENTIFIC
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OFFICIAL ORGAN OF THE
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ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,
32. VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

Railway Carriage Lighting.

The discussion on Railway Carriage Lighting at the last meeting of the Illuminating Engineering Society on April 7th, furnished an interesting illustration of the value of the work recently undertaken by the Society in connection with the lighting of schools and libraries. This work was directed largely towards establishing a standard of illumination for reading purposes; and as most people nowadays expect to read during a journey of any length, it is evident that the similar conclusions might be applied to railway carriages and other public vehicles.

In investigating this problem the same procedure was followed as in other cases. Through the courtesy of the engineers of a number of different railways measurements were made by Mr. Dow in a series of typical railway carriages. It would appear from these tests that the desirable minimum reading illumination could be obtained without difficulty in a modern well-lighted compartment. We thus find that the recommendation one would be disposed to make on theoretical grounds is shown by practical experience to be easily complied with.

The question has been raised whether, after all, the main purpose of carriage lighting should be to enable people to read. There are some who do not wish to do so and who complain of over-brilliant lighting. But we think that this view will, on analysis, prove to be founded on an objection to glare, rather than to the intensity of illumination. If the lights were properly shielded from the eyes few people would be found to complain of excess of illumination on the printed page.

Another point on which stress was laid in this discussion was the flickering of lights and the effect of vibration. The shaking of a book or newspaper makes it difficult to read in many tramcars and buses, &c., and even in some railway carriages. Nevertheless, very considerable progress towards smooth running has been made in recent years, and on long-distance journeys there is not a great deal to complain of in this respect.

A third point is the desirability of using better methods of shading the lamps. Several speakers urged that long rows of bare filaments, met with particularly in tubes and tramcars, are very trying to the eyes. We are glad to see that on some of the most up-to-date railways, improvements in this respect are now being made, and we feel sure that as time goes on the value of proper shading, both from the economic standpoint and with a view to the comfort of passengers, will be more fully appreciated.

The conclusion to which one is driven by these discussions is the need for a special illuminating engineering department on a railway of any size. Under the present system there is no opportunity for specialisation, and one would imagine that much valuable experience acquired in some departments is not utilised in others. If *all* the lighting were considered by one expert, whose duty it was to keep the company informed of all the latest developments in this section, much good would ensue ; and it cannot be doubted that this course, besides leading to improvements in illumination, would often enable substantial economies to be made.

It is difficult to over-estimate the importance attached to the lighting of vehicles by the public. The many comments in the daily press on the recent meeting of the Illuminating Engineering Society show that this is a subject of special interest. The hope is expressed in several quarters that the Society would keep the matter to the front and steadily exert its influence in favour of better illumination, and this will doubtless be done.

Illuminating Engineering Calculations.

In this number we publish the discussion of Mr. Clinton's paper on the above subject read before the Illuminating Engineering Society on March 17th. We commented on the paper in our last issue, but there are several points that have been raised in the discussion, and in the technical press, since the date of the paper on which something further may be said.

In the first place we should like to point out that because Mr. Clinton has worked out his results with exceptional care, it does not follow that such detailed calculations would always be necessary in practice. The object of the paper was to show that it is practicable to predetermine illumination with sufficient accuracy ; it was therefore obviously desirable to take every precaution, and to allow for all the various factors, so that the results might

be expected to come out as closely as possible. In practice, no doubt, one might often be content with "short cuts" and with a more approximate order of accuracy. But this in no way detracts from the value of exact calculations in this particular case.

For until accurate researches of this kind have been made it is difficult to trace the very various sources of uncertainty and ascertain how near one can really expect to predict results. Once this preliminary work has been done it becomes much easier to make short cuts in practice, with a knowledge of the probable error which these approximations will introduce.

Again, we are of course prepared to admit that the numerical value of the illumination provided, although a most important factor in the success of an installation, is not the *only* element to be considered. The physician recognises the value of the clinical thermometer; but he does not expect the instrument to tell him whether the patient is suffering from influenza, smallpox, or appendicitis. He requires other information, although he knows that the reading of the thermometer, *properly interpreted*, is sufficient indication that something is wrong. Similarly the illuminating engineer must naturally consider many other factors besides the actual intensity of illumination provided; and yet this still remains a vital point, particularly in connection with industrial lighting.

This analogy may be carried a little further. The illuminating engineer may be compared to the physician, the public to the patient, and the manufacturer of lighting appliances to the chemist responsible for making up the doctor's prescriptions. It has long been recognised in the medical professions that prescriptions should be made up in an accurate and responsible manner. Unless *both* the physician's prescription and the material supplied by the chemist in accordance therewith are correct, the patient is not likely to benefit. At the present time wise people take their prescription to a qualified chemist and not to a quack. Similarly it is of vital importance to the lighting industry that the particulars furnished by manufacturers about their lighting units should be exact, so that those who make use of them may have confidence that a lamp or reflector will do what it is stated to do. Irresponsible figures, which may be likened to quack prescriptions, should be discouraged.

One of the chief conclusions to be drawn from the paper, therefore, is the importance to manufacturers of being in a position to furnish polar curves and all needful data about their units. Most of the big manufacturers are now equipping laboratories in which such data can be obtained, and a practice is being made of applying to the National Physical Laboratory for certificates when a high degree of responsibility and accuracy is to be attached to the results presented. In this way they can secure results backed by the hall mark of a genuine and recognised impartial authority. It is clearly essential that work of this kind should be carefully carried out, and that any data which are put forward as representing the result of an impartial outside test should bear the *closest scrutiny*.

The equipment and maintenance of a modern photometric laboratory is an expensive matter, not to be lightly undertaken. Work carried out with an inferior and incomplete equipment would never receive wide recognition, and any attempt to assume responsibilities such as those referred to above, without the truly impartial and authoritative position which alone can justify them, would never command the respect of lighting industry and would be foredoomed to failure.

Public Lighting in Glasgow.

In a recent number of the *Glasgow Herald* reference is made to an interesting development in the city's lighting. Hitherto there has been a rather anomalous distinction between the lighting of so-called public streets and "private" streets, closes, &c., the illumination of which was imposed on private owners of property, a curious echo of the days when there was no public lighting, and each householder was compelled to hang up a lantern outside his premises.

The system may have answered fairly well in the year from which the regulation dates, 1866, when the city only spent £26,000 on public lighting; but it is quite out of place to-day, when the lighting of Glasgow costs no less than £136,000. For to-day there are not, strictly speaking, any "private" streets; the public uses freely the places so described. It is calculated that at least 900,000 citizens make use of one "common stair" in entering their homes in the course of the year. It is common knowledge that such places as are left to private enterprise are almost invariably badly lighted. The private person grudges, or at any rate is too busy to supervise, proper lighting outside his home, and "it is a familiar fact," says the *Glasgow Herald*, "that close-lighting is at its worst where the need of it is greatest as an ally to good order, public safety, and public morals."

Accordingly it is proposed to take over all such lighting and for the Corporation to levy a rate on landlord and tenant, each of whom will pay 3d. in the £1 and be freed from all responsibility. It is hoped that by this means much friction between landlord and tenants as to the quality and price of stair-lighting will be removed.

The Lighting of Parks and Commons.

In conclusion we should like to point out that the lighting of parks and commons is, strictly speaking, as much "public lighting," and in some respects quite as needful, as the lighting of streets and other open spaces.

A short time ago, in referring to the "lighting of London," we pointed out that much more might be done to make the lighting of the London Parks attractive by night. The method of lighting only one section of a public park causes people to congregate in these regions and leads to overcrowding. If the park as a whole were lighted a much larger area would be used by the public, who would derive more benefit than when restricted to a small dust-laden area.

In the interests of order, suitable lighting is also desirable. We observe a correspondence in the press with regard to the supervision of Hampstead Heath, and we imagine the conditions on many of the commons in London County would be very similar. It is suggested that some form of supervision is necessary in these places by night. We would suggest that by far the best policeman in such cases is abundance of illumination. It is the darkness that encourages wrong-doing. If these places were adequately lighted the possibilities of evil would be greatly diminished, and the work of those responsible for law and order much simplified. It may be suggested that the experiment of providing more general illumination should be tried first in some of the larger parks. We feel sure that the good results secured will lead to a general improvement in park lighting.

LEON GASTER.

TRANSACTIONS

OF

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The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

A COMPARISON OF ESTIMATED AND OBSERVED VALUES OF ILLUMINATION IN SOME LIGHTING INSTALLATIONS

(Discussion of a paper by Mr. W. C. Clinton, B.Sc., read at a Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m. on Tuesday, March 17th, 1914; see pp. 189-215 in last issue.)

Mr. A. P. TROTTER said this was the first paper that the Society had received on the calculations of actual examples of illumination of this kind. He would like to ask Mr. Clinton whether he found any difficulty in the practical use of the Kennelly curve. This curve had to be built up from point to point, and the lower part of it was comparatively unimportant, in the sense that the light was falling upon a small area of the floor of each zone, but as one crept up the hemisphere more important zones were reached, and if the drawing was not rather carefully made, there might be a cumulative error. It had always seemed to him that the Russell modification of the Rousseau curve, where a very few points sufficed, gave a more definite value, and it could be stopped at any point at will. It was not necessary to draw the curve, but only to take the mean of the radial values at the Russell points.

The question of reflection was of great importance, and he would like to ask the author whether the reflection coefficient of which he spoke was the summation of the repeated reflections, or whether it was the simple coefficient of the surface of the wall as a reflector. If the walls, ceiling, and floor had a coefficient of diffused reflection of 0·4 (the value given by Sumpner for yellow wall paper, and clean deal wood), the sum of the repeated reflections would give $1/(1-0.4)=1{\cdot}66$. The illumination would be 66 per cent. higher than with direct light and black walls. But the walls and floor were not of the same colour as the ceiling. Half of the walls and all of the floor might be considered black. An addition of 66 per cent. would then require a coefficient of ·8 for the upper part of the walls and for the ceiling. This is very high, and is that of clean white paper.

It was most important that we should be able to get the true data in these cases, to work backwards, and to predict, as had been done in the paper, from those data the lamps to be used, and the result which would be found. The concordance between the calculated and observed results reflected extreme credit on Mr. Clinton, and demonstrated the very satisfactory stage at which illuminating engineering had arrived.

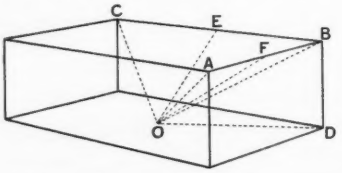
The lighting of the Lecture Theatre of the Institution of Civil Engineers offers a good example for calculation. The photograph, which was taken at night by Mr. V. H. Mackinney, is reproduced by permission of the Secretary of the Institution. The system is similar to that used at the Institution of Electrical Engineers, but the general effect is better because the brightness of the cove is more intense. The white ceiling contributes by secondary reflection, though this, and the light received from mercury arcs above the dome, is a good deal less than is suggested by the photograph.

The illumination at the level of the table was from 1·9 to 2 foot-candles, and the brightness of the cove measured by a lumeter was between 20 and 25 foot-candles. That is to say, it was equal to the brightness of the standard lumeter card when this receives 20 to 25 foot-candles.

The Theatre is 60 ft. by 40 ft. The height from the table to the middle of the cove is 20 ft. The width of cove visible is about 3 ft. Taking the brightness at 22 foot-candles and the coefficient of diffused reflection at 0·75, then each square foot of cove gives $(22\times\cdot75)/\pi=$ 5·25 candle-power normally—say 15 candles per foot run. The long sides may be regarded as filaments of 900 candle-power each, the short sides 600 candle-power. The simplest formulæ for finding the illumination at, say, the middle point of the Theatre is the one given by Fleming in *Phil. Mag.*, Vol. 10, 1905, p. 212.*

Let AB and BC be two sides of the cove, and O the point at which the illumination is required.

AB = 40 ft. = 600 candles. BC = 60 ft. = 900 candles. BD = 20 ft. OD = 36. OB = 41·2, OE = 28·28, OF = 36.



Then by Fleming's formula,

$$\tfrac{1}{2}(\mathrm{Cos}^2\phi+\phi\mathrm{Cot}\phi)$$

where ϕ is the angle BOE expressed in radians we obtain the correcting factor for the candle-power of the filament at a distance so close that the law of squares does not hold.

EB/EO=tan 46° 42′=·815 radian.
FB/FO=tan 29° = ·506 radian.
$\frac{1}{2}(\cdot686^2+(\cdot815\times\cdot940)=\cdot618$
$\frac{1}{2}(\cdot875^2+(\cdot506\times1\cdot8)=\cdot838$

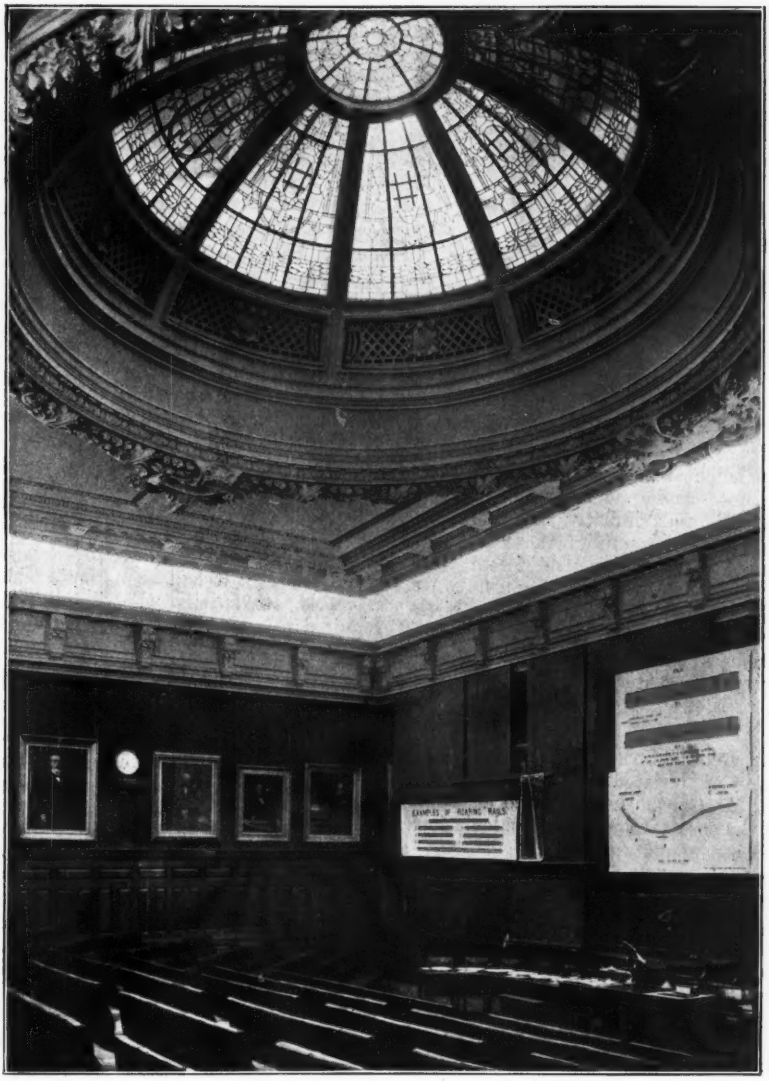
Illumination = (candles/distance^2) × cosine of angle of incidence.

$$\left.\begin{aligned}\frac{556}{800}\times\frac{20}{28\cdot28}&=\cdot49\\ \frac{502}{1300}\times\frac{20}{36}&=\cdot219\end{aligned}\right\}=\cdot709 \text{ for 2 sides}=\cdot1\cdot42 \text{ total.}$$

This accounts for three-quarters of the observed illumination, the remainder being due to the secondary reflection from the ceiling and to repeated reflection from the walls, and to the mercury lamps. On the other hand, assuming that three-quarters of the illumination is directly due to the cove, this gives 15 candles per foot-run as a fair value for the cove as a source of light, and from this and the observed value 22 we obtain ·71 as the coefficient of diffused reflection of the cove.

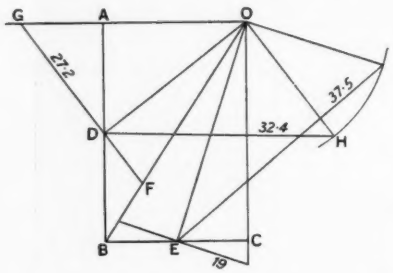
As an approximation, consider one quarter of the theatre OABC, to scale, the middle point being O, and AB being half the long side and BC half the short side. Draw the diagonal OB and draw OD and OE to the middle points of AB and BC. Draw GF at right-angles to OD. This represents the side AB swung round to face O. Similarly draw a line through E at right angles to OE. The line GF scales 27·2 ft. and the other line 19 ft. At 15 candles per foot-run these are equivalent to 408 and 285 candles.

* Quoted on p. 122 of my book on Illumination, on which there is, by the bye, a misprint of — for + in Hyde's formula.



A view of the Lecture Theatre of the Institution of Civil Engineers, London. The illumination is derived mainly from the white frieze lighted by concealed lights, and there are also mercury vapour lamps above the glass in the central dome. From a knowledge of the dimensions of the room and the area and surface-brightness of the illuminated frieze it is possible to estimate the illumination provided at the level of the seats and Council table (Mr. A. P. Trotter).

The point at which the illumination is to be found is 20 ft. below the cove. From O draw an arc OH of 20 ft. radius, and draw OH at right-angles to OD. Join DH, then DH, which scales 32·4 ft., is the slant height from the point D on the cove to point H 20 ft. below it, and



20/32·4 is the cosine of the angle of incidence. From the square of the slant height and the cosine we obtain ·240 foot-candle for the illumination from AB, and similarly ·108 from BC. Four times the sum of these is 1·392, which is only 2 per cent. different from the former result. (Probably a fluke.)

The radius of the equivalent circle may be found and is about 25 ft. The relation is the same as that of the magnetic force due to a rectangular coil and to a circular coil.

Mr. LEON GASTER said he was sure all present appreciated the great amount of work Mr. Clinton had put into his paper and the care with which his calculations had been made.

In these calculations Mr. Clinton had preferred to go right back to first principles, and to work out the illumination from a knowledge of the polar curves and the positions in which the sources were placed. This was desirable in order to make the calculations of general application to all systems of lighting.

Manufacturers of lamps and fittings, many of whom a few years ago scarcely knew what a polar curve meant, now habitually furnished such data about their units. He therefore wished to emphasise the importance of having these curves determined in an accurate and responsible manner, so that those who used them could feel sure of their being quite reliable. He would also suggest that both the curve of the bare lamp and the curve of the lamp in the globe or reflector should be given; and that the candle-power in any direction should be clearly indicated.

It is also most essential that all such particulars should be kept up to date. As new illuminants come along the nature of the curves may be entirely altered.

Mr. Gaster exhibited two data books, one referring mainly to electric lighting, the other dealing with gas lighting, prepared by the two firms in the United States. The good plan is followed of issuing additional sheets from time to time to replace obsolete ones. Such information is most useful to the contractor; without it he naturally cannot estimate the resulting illumination with any accuracy.

Mr. Gaster pointed out that in the various recommendations so far issued on lighting (such as those of the Joint Committees on the Lighting of Schools and Libraries), it had been found most desirable to specify the illumination required in numerical terms. No doubt the same would apply to other branches of illumination. It was evident, therefore, that manufacturers would find it a great advantage to be able to supply data, enabling the illumination obtained by their system to be calculated out beforehand; so that anyone using such information could feel confident what the resultant illumination was going to be.

Moreover, in the higher branches of illuminating engineering, where new and original problems had to be solved and previous experience might not be much of a guide, the ability to calculate out the resultant illumination from first principles might make all the difference between success and failure.

Mr. Gaster referred to the work of Mr. C. E. Clewell, and laid stress on the desirability of *maintaining* the illumination by prompt renewal of defective lamps and burners, and by attention to the cleaning of shades and reflectors at frequent intervals. People recognised the importance of cleaning windows, which admitted daylight. Why should

not the same care be devoted to the fittings by which the artificial light was received?

In conclusion, Mr. Gaster said that Mr. Clinton's paper would be read with much interest by many outside the Society as well as by its own members, and he believed that in time to come it would be recognised as one of the most important contributions yet received.

Mr. JOHN DARCH asked for a little more information about the Kennelly curve.

With regard to the ascertained amount of illumination falling on a surface, he had nothing to say against the excellent paper presented to the meeting, but he felt that such a paper might lead many engineers to rely too exclusively upon measured illumination. It was very important not to forget the effect of the surroundings upon the eye. This, as a rule, had a very real effect on our appreciation of any particular quantity of illumination. For example, take a bench with a number of reflectors upon it, such as tools or material; the real appreciation of illumination or, in other words, the amount of light that actually came into the eye—because the pupil would be closed if there was sparkling—was of more importance than the actual amount of light that was measured. A scheme was set up for four or five or six foot-candles on a work bench, but we entirely overlooked the effect of dazzle. The effect of reflection from a dado and the surroundings might be that the lighting while being photometrically increased would *virtually* be reduced from four or five foot-candles to an effective two or three.

Mr. J. G. CLARK said that one of the most important things which the Society had done during the past year or two was to specify some minimum values for certain special purposes, and in this direction the work of Mr. Clinton was a very great step in the problem of practical lighting. He had shown the relation between calculated and observed values and had made it fairly clear that, if carefully done, calculation could help in planning an installation. For his own part he found the flux method a handy one to arrive at average illumination.

In many such calculations the "point to point" method was probably the best, but Mr. Clinton had not mentioned a little calculator that formed a ready means for arriving at these values. There were, he thought, two or three types, but he had found the Macbeth very handy.

It was an interesting fact that although one might have lighting units with very different forms of shade giving quite different polar curves, the resultant effect, based upon average illumination, was remarkably similar. It was interesting to notice this, because the problem might be regarded in two ways, first by ascertaining the amount of energy, either gas or electricity, to provide the total flux—that was based upon the average illumination—and, secondly, to arrange the units so that the light is distributed in such a way that a large quantity of light was not given in one place and a small quantity in another.

One reason, probably, why the efficiency did not vary was because we did not in many cases aim at throwing too much light on the walls. Reflecting shades and other reflecting surfaces around the lamps reduced the importance of the walls, so that even with a variation in the coefficients of reflection from walls one did not get always a very marked difference in the average lighting efficiency on the working surface. The general aim was to keep as much light as possible from the eye. Some time ago he started collecting data for various installations, and it occurred to him that it would be a good plan to extend this and to take a number of installations, the data of which were known, and deal with them in order to arrive at some sort of classification which would give a means by which we could repeat results from known data. He had not yet been able to collect very much data of this character himself, but perhaps some day a whole collection on these lines might be made. He was struck by the high efficiency of the indirect installation as compared with the direct as given in the paper. His own experience shows that the efficiency of the indirect

system is lower than the direct system to a greater extent than was found by Mr. Clinton.

The author had not touched upon street lighting, probably because that was a relatively simple problem, there being no reflection from walls to consider. Reflection from walls in street lighting was varied and uncertain, and it was probably better to ignore it altogether. In looking at the diagram given by Mr. Clinton of the illumination on a working bench, the differences between the calculated curve and the observed curve rather suggested that the polar curves of the lamps were not the same. The calculated curve in the centre was appreciably higher than for the two side lamps.

Mr. CLINTON said he thought there was a difference in the distance between the lamps.

Mr. J. G. CLARK (*added*): Since the date of the meeting I have had an opportunity of reading Mr. Clinton's paper, and would like to tender a few supplementary observations on one or two points.

First, in regard to bench lighting, of which Fig. 16 in the paper is an example. It occurred to me that owing to the nearness of the source of light to the working surface, namely, the work-bench, there might be a serious deviation from the law of inverse squares. In taking measurements for polar curves it is usual to have a radius, not less than six feet, at which distance it is believed there is no serious deviation from the law of the point source, due to parallelism of the rays. When the radius is very short, however, some serious deviation might occur, and with a view to ascertaining if this is so, I made some observations which disclose the following relation.

A unit with a deep reflecting shade similar to that illustrated by Mr. Clinton in Fig. 16 was arranged so that the illumination at two distances, namely, 51 and 33 inches immediately underneath, could be determined.

The results show that if the illumination at 33 inches is calculated from the observed value at 51 inches, the result is 10·8 per cent. too high. The actual readings were as follows:—

Distance from unit. inches.	Actual read. observed. foot-candles.	Calculated read. foot-candles.
51	·583	—
33	12·45	13·9

This may explain the want of agreement between the calculated and observed results shown in diagram 16. If so, it is clear that some care must be exercised in the use of polar curves, especially in the case of deeply shaded light sources used near to the working surface.

Mr. Clinton drew attention to the loss of light through windows. In the case of the class-room analysed in example 5, he records a "utilisation factor" of only 60 per cent. This would point to the advisability of providing light coloured blinds in places where the window area is rather large.

I am, however, not sure that Mr. Clinton's figure of 60 per cent. truly represents the efficiency of the installation. In calculating the values given in Table VIII. five positions of maximum illumination are averaged with eight positions of minimum illumination; but I think it is doubtful whether the average so obtained, namely, 3·7 foot-candles, represents the average illumination of the working surface. If the illumination of the working surface, that is, the desks, be taken as a criterion, the diversity coefficient will be found to work out at less than two, whereas the figures in Table VIII. indicate a diversity coefficient of about 13, showing, I think, that insufficient and unsuitable points were chosen to accurately deduce the "utilisation efficiency." A more detailed calculation would show that in spite of the large window area the utilisation efficiency would be higher than 60 per cent., for if "utilisation" means anything it means the amount and disposition of the light upon the *working surfaces*, and in a class-room this leads us to refer to the desks, not to a horizontal plane adjacent to the walls. If light were required so near the walls as the points A.....H chosen by Mr. Clinton, then a rearrangement of the light sources would be advisable.

I should like to take this opportunity of thanking Mr. Clinton for his paper. It is one which indicates the extent to which theory can be applied in practice, and if the problems are viewed from the standpoint of practical requirements, theory can guide us to the most suitable methods.

MR. THOMAS E. RITCHIE asked the author whether the coefficient of reflection for the white frieze given for item 7 in the paper as 66 per cent. could also be taken as applying to the ceiling, which he presumed was an ordinary whitewashed ceiling, as the figure in question seemed to him (the speaker) somewhat high for the generality of ceilings of this description.

He would also like to ask the author whether, as a result of the inspection of the various saw-tooth roofs which he had doubtless examined, he had formed any conclusion as to the coefficient of reflection of the long slope of such roofs, which was usually boarded, and was generally far from white.

Any information which Professor Clinton could give upon such points would be of the greatest value to those actually engaged in the predetermination of illumination under the widely differing conditions met with in practice, as whilst to all such the theoretical calculations were exceedingly interesting and important, far and away the most difficult problem which they had to face was that of determining with any degree of accuracy by what amounts the value so arrived at must be reduced in practice.

In the case of arc lamps at all events the difference between laboratory tests and service conditions were such as to prevent the securing of a measure of agreement between calculated and observed values which could only be described as remarkable in the extreme. Excellent *characteristic* agreement could, as Prof. Clinton had shown in Fig. 25, readily be obtained, and the establishment of that fact was he thought of considerably more importance than the correctness or otherwise of the particular coefficients used in any particular case.

Mr. Gaster had raised an important point when he touched upon polar curves, and more especially upon the necessity for such curves showing the light distribution of the source with and without the globe or shade used with it. Obviously in this case Mr. Gaster was referring to incandescent lamps and mantles, and not to arc lamps, as the polar curve of an arc lamp, to be of the slightest value commercially, must be taken with the particular glassware with which it was to be used.

He was not quite clear as to the reference to "ageing" made by Professor Clinton, in respect of item 4 in the paper. It appeared to be used in relation to a falling off in the value of the light reflected by the walls of the booking hall described, in which case the reference to the author's figure 13 seemed somewhat obscure.

As far as he (the speaker) was aware Mr. Clewell's figures related to incandescent lighting and covered the losses due to (*a*) the loss of reflected light (if any) from walls and ceiling, (*b*) the loss due to the depositing of dirt and dust upon both the lamps and shades, and (*c*) the "ageing" (*i.e.*, the falling off in the candle-power) of the actual light sources.

In the case of arc lamps the necessarily regular trimming and cleaning did away entirely with items (*b*) and (*c*) and ensured the maintenance of the maximum efficiency for an indefinite period and the elimination of most, if not all, of the 40 to 45 per cent. loss shown by figure 13. He thought that this should be made quite clear, as there was a tendency in certain quarters to regard the cost of trimming as unremunerative instead of, as was really the case, an investment of a very profitable character.

If Professor Clinton could give any figures as to the falling off in the illumination due to the ageing of wall and ceiling surfaces only it would be very valuable. He (the speaker) thought that such losses would prove very small, as many installations of arc lighting were extant in which the falling off after several years was of quite an insignificant character.

The question of the Kennelly curve as used by Professor Clinton had been touched upon by previous speakers. As the paper would undoubtedly be retained by many for reference purposes, he thought it would be wise if the reference to this construction could be reprinted and included as an appendix to the paper, as both the publications in which it originally

appeared were now out of print. Meantime it might interest some to know that candle-power values determined in this way from the polar curve and without any special precautions in the construction agreed in certain cases of which he had knowledge within quite a small margin with those obtained by the use of the Ulbricht globe.

Mr. JOHN LOVIBOND pointed out that Mr. Clinton, throughout his calculations, had assumed that the illuminations received on a surface from various sources of light could be added arithmetically in order to estimate the resultant illumination. Physically this might be so, but he (Mr. Lovibond) doubted whether it was correct physiologically. In his own work he had found that the increase from one candle to two candles did not necessarily double the *effect* of the light; it might only add about 1 in 10 to it. In some circumstances, when the light provided was less than 1 candle, he doubted whether a small increase in illumination had any material effect on the physiological luminosity.

MR. V. H. MACKINNEY remarked on the excellent agreement shown between the calculated and observed values of illumination in the installations described by Mr. Clinton. But it should not be forgotten that there were many variable factors, influencing the efficiency of an installation; and that one naturally could not expect an installation, that had been left for months or years, to continue indefinitely to give the illumination originally estimated. If after 6 months the illumination had not diminished more than 20 per cent. the consumer would have no cause to grumble. He was, therefore, glad to see that Mr. Clinton had laid stress on the need for maintenance. Other points to be considered were the specific consumption of the lamps installed, the permissible variation in the line voltage and its effect on the candle-power of the lamps, and the influence of surroundings.

Mr. Clinton had worked out his calculations in a very painstaking manner. In practice, lighting engineers would often be able to make a sufficiently near estimate of the illumination by applying rules giving the watts per square foot per foot-candle for the system of lighting used. In this connection it was important to recognise that a somewhat different result from that reached with a single point would naturally be obtained when there were a large number of uniformly spaced points. Some data on this subject had been presented in Germany and the United States, and the company with which he was connected had recently published a series of tables for particular units, showing the "utilisation efficiency" for 1–64 points. When 64 points were installed the percentage of the total lumens reaching the working plane was as high as 60 per cent.; whereas with a single point it would be less than half this value.

The chief source of uncertainty in illumination calculations was undoubtedly the effect of reflection from surroundings. The Sumpner formula involving the geometrical progression had often been quoted; but on closer examination it would be seen that this formula applied chiefly to the brightness of the walls and really gave little information as to the influence of reflection from walls on the illumination over the working plane. The actual effect would depend not only on the type of reflector used but on the shape and size of the room. The influence of the size of the room was apt to be ignored in some of the tabular data put forward on this subject. In a large hall the influence of the walls and ceiling was often very small indeed; in a very small room they often made a surprising difference to the illumination, even when direct lighting was used.

Finally, Mr. Mackinney remarked that the application of the polar curve in practice assumed that the inverse square law held good, even for reflectors of a concentrating type. As a result of a series of experiments on various well-known types of reflectors he had formed the opinion that this assumption was quite sufficiently justified as far as commercial accuracy was concerned, and it was interesting to observe that a similar conclusion had been reached quite independently by E. J. Edwards and Ward Harrison.*

* Trans. Am. Illum. Eng. Soc., Dec. 1913.

Mr. WILLIS referred to an indirect lighting installation which he had carried out with Mr. R. A. Smith, in the Vauxhall Bridge Road. The specification stipulated the use of inverted type of arc lamp with semi-luminous reflectors. After going carefully into the calculations, it was decided to take an average value of 3·5 foot-candles on the working plane, which was taken as 3 ft. 3 in. from the floor. After two years an average figure of 3·207 foot-candles was obtained by photometric measurement. The diversity coefficient was 2·3, and he obtained it in exactly the same way as Mr. Clinton had illustrated in the paper. He showed a number of slides illustrating this indirect lighting installation. The lamps were hung 2 ft. 6 in. from the ceiling in rooms 11 ft. 6 in. high, and 3 ft. from the ceiling in rooms 13 ft. 6 in. high, the lamps being fixed at 17 ft. centres in square formation. (*See illustration.*)

The most interesting part of this proposition was the necessity for colour matching; the buyers stating that it was impossible to match colours, particularly in silky materials, by artificial lighting. In order to deal with this problem, experiments were carried out with six different types of arc lamp, and as a result it was decided to install indirect arcs with semi-luminous reflectors, as it was found that this was the only form of artificial lighting by which colour matching could be carried out.

Mr. JUSTUS ECK said that he also had been struck by the remarkably concordant results obtained from calculations made and measurements made especially in the case of some of the installations of incandescent electric lighting.

He was also interested in the reference to ageing made by Mr. Ritchie. This seemed to him a most important point, because if as a result of their calculations

they were going to put forward values which would only hold good at the first test when everything was absolutely new, they would be misleading everybody and losing reputation.

It would therefore, he thought, be well if the attention of the Society was directed to the carrying out of some systematic tests of this nature extending over a considerable period, because if it were found that losses of the order of from 30 to 40 per cent. of the original illumination were as commonly met with as he understood they were in certain types of lighting, then it was well to realise that all installations subject to such losses required regular maintenance to bring them up to the original efficiency and not only to realise that this work required carrying out but to suitably impress the fact upon the users and see that the work was done at sufficiently frequent intervals.

Very few people who had lighting realised what a valuable asset they were buying for a very small sum of money. A properly lit factory would produce just as rapidly by night as by day, and as in this part of the world there were many days that were more like nights it followed that if lighting installations were so maintained as to give continuously the correct illumination they would give very valuable service to the owner and would more than repay the expenditure involved.

Mr. J. S. Dow said he had had personal experience of the great trouble taken by Mr. Clinton in the preparation of the paper. In some cases the calculations were worked out in greater detail than would be necessary in practice, and naturally an engineer, who was constantly dealing with installations of a particular variety, and constantly making tests of illumination therein, would come to rely on his experience to a great extent.

But when one came to novel types of installations, and had little experience to fall back upon, calculations were essential. In the higher branches of illuminating engineering, where there was a blending of the creative skill of the artist and the technical knowledge of the engineer, such cases would often arise. In dealing with light transmitted through large sheets of diffusing glass, or reflected from arches, alcoves, friezes, and mouldings, it might often be very difficult to predict from empirical rules what the illumination would be. The frieze lighting in the Institutions of Civil and Electrical Engineers was a case in point.

Mr. Clinton had shown that calculations with direct lighting were comparatively simple; it was the reflected light that required such special estimation. He wished Mr. Clinton would carry on some of Dr. Sumpner's early work by determining the absolute reflecting power of a variety of materials and presenting samples marked with the values determined. In estimating reflection from walls and ceilings, at present one had to make something in the nature of a "shot."

It appeared that a very considerable number of cases of indirect lighting—where practically all the light from the lamps went direct on the ceiling, and where the walls were light and thus equivalent to an extension of the ceiling area—might be very easily dealt with by regarding the ceiling as an infinite illuminated plane.

During a recent visit to the Arts and Crafts School in Southampton Row, he had been rather astonished to find that in a drawing office lighted with indirect arcs the illumination over the greater part of the room was as much as 18—19 foot-candles. It was only after checking the instrument again on his return that he felt satisfied that a mistake had not been made. The room has approximately the following dimensions:—47½ ft. long, 25 ft. wide, and 14 ft. high. The floor area is thus approximately 1,200 sq. ft.

It is lighted by six inverted arcs, in all consuming 3,000 watts. Taking the average illumination all over the room at 16 foot-candles, the watts per lumen thus work out to:—

$$\frac{3000}{1200\times 16}=0{\cdot}15 \text{ approx.}$$

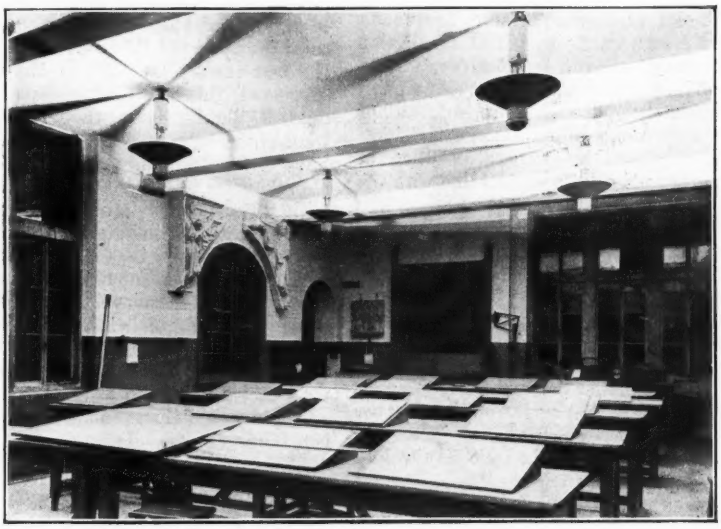
This is, perhaps, a low figure, but the new white ceiling and white walls extending down to about five feet from the floor made the conditions exceptionally favourable.

Now, assuming that these arc lamps yield in all $3000\times 4\pi$ lumens, that 75 per

cent. of the light is directed on the ceiling, and that 75 per cent. of this is reflected downwards, the brightness of the ceiling should be :—

$$\frac{3000\times 4\pi}{1200}\times\frac{75}{100}\times\frac{75}{100}=17{\cdot}6 \text{ foot-candles.}$$

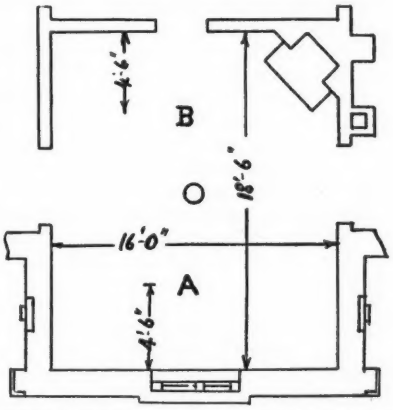
to be lighted, I would like to point out that this method is likely to lead to very divergent results depending upon many varying factors, such as the size of the room, height of ceiling, nearness of walls, colour of walls, &c., unless allowances



A Drawing Office lighted by indirect arcs. If the ceiling is treated as an infinite illuminated plane the calculated illumination (17·6 ft.-candles) agrees quite closely with that actually measured.

If we regard the ceiling as an infinite illuminated plane the illumination in the centre of the room should equal this value. And this is in quite good agreement with that actually recorded. The calculation thus verifies practical experience.

Calculations for some other rooms in the same building lighted in the same way, but having dark walls, also gave fair results by this method; but one would probably have got still closer in these cases by regarding the ceiling as an illuminated rectangle instead of an infinite plane.



Plan of Library illuminated by a 100-watt lamp in indirect bowl.
Illumination, measured in a horizontal plane, 3 ft. 3 in. from floor :—
Under lamp, 1·7 ft.-candles.
At A 1·35 ft.-candles. At B 1·5 ft.-candles.

MR. R. I. WALLIS-JONES (*communicated*) :—

With regard to the method sometimes adopted of estimating the illumination (indirect) in foot-candles by allowing so many watts per square foot of the area

based upon experience are made. In the example shown a room 18 ft. 6 in. long and 16 ft. wide is lit by one single indirect pendant with metal bowl reflector, having one 100-watt tungsten lamp. At the time when the readings were taken the bookcases which surround the room were draped with soiled grey-white dusting sheets, and were therefore equivalent to walls of a light tint. The installation was a new one, and readings were taken 3 ft. 3 in. above the floor line. At a point immediately under the lamp the readings gave an average illumination of 1·7 foot-candles. Readings were also taken at two other points in a central line with the fitting and 4 ft. 6 in. from the walls. The net result was that an average illumination of 1·51 foot-candles was obtained. If, however, the illumination were calculated from a well-known formula based upon watts per square foot, instead of 100 watts being sufficient, 157 watts would be the calculated amount necessary to give an illumination of 1·5 foot-candles.

Referring to the suggestion that further work should be done in the way of experiments to determine the reflective values of wall papers of various colours, I would point out that one of the great difficulties in carrying out these experiments is to be sure that exactly the same tint is reproduced for comparison in the future, and I would suggest that whoever experiments in this direction should adopt the standard of colours shown on a colour-sheet known as "Répertoire de Couleurs pour aider à la détermination des couleurs des Fleurs, Feuillages et des Fruits," published by the Société Française des Chrysanthémistes et René, Oberthür.

This was successfully used by the late Mr. Halford in his book on "The Modern Development of the Dry Fly," where it is of very great importance to get the exact tint reproduced in the fibres, hackles, &c.

Mr. F. HARVEY GOOCH (*communicated*) :—

As a keenly interested member of the audience, I should like to thank Mr. Clinton for his valuable paper. I so often meet cases in which a contractor has put up a lamp and reflector on some rule-of-thumb plan where he "thinks" it ought to go—and expects good results—that such a presentation of methods of calculating illumination should be heartily welcomed.

In the course of his lecture Mr. Clinton showed two curves illustrating the diminution in candle-power in installations where the lamps and reflectors are not cleaned. It appears that the illumination fell continuously for about 18 days, and then remained practically constant up to the thirty days over which the test took place. If, as Mr. Clinton suggested, this was due to deposition of dust, I should have thought the fall would have been more gradual and would have extended throughout the entire curve. Now, if these tests were made with metal filament lamps the deterioration might have been partly due to the fact of the initial candle-power being higher than the nominal or rated candle-power. This, I believe, is characteristic of metal lamps, the behaviour of which is somewhat irregular in the early stages of their life, and it would help to explain why the illumination values at first fell so rapidly and then remained practically constant.

This supposition would also partly account for the fact that the calculated values of illumination were almost invariably higher than those actually obtained. It would be interesting if Mr. Clinton could obtain data for some of the installations described bearing on this point. On the above supposition it would doubtless be best to make observations of installations after the lamps have been burning for some time, and not when they are actually new.

Mr. W. C. CLINTON, in reply, referring to Mr. Trotter's remarks, said that the Kennelly construction had been used in preparing the diagrams for the paper, as it was very easily and quickly made, did not involve the estimation of any area, and gave the mean spherical or mean hemispherical candle-power of the source, or, if it were required, the total flux of light up to any angle from the vertical, directly as the length of a straight line on the diagram. The method had been found to give results in very close agreement with those obtained by the longer Rousseau method, with zones as wide as 15°.

The coefficients of reflection given by Dr. L. Bloch and used in the paper were the ratios of reflected to incident light after a single reflection. For large rooms of moderate height in which the effect of the floor and part of the walls is negligible, this is probably the best figure to take.

Mr. Trotter has given a very simple method of dealing with a problem in cove lighting, by reducing the cove to a line of light, and then using a correcting factor to allow for the fact that the line was a long one compared with the distance of its centre from the test point. Although the difference in this particular instance is not appreciable, it may perhaps be worth while to point out that the correcting factor used is valid for a line of light radiating equally in all directions perpendicular to itself, but that if a more or less flat surface such as the cove in question is reduced indefinitely in width, the resulting thin strip would radiate from every element still as a flat surface, and that the reduction formula for this condition then becomes :—

$$(\tfrac{1}{2}\cos\theta+\tan^{-1}\sin\theta\cot\theta).$$

The calculated value of the illumination from this and the other data is then 1·45 foot-candles.

It is also possible to solve this problem by determining the illumination due to luminous rectangles equivalent to the cove. This calculation gives a figure of 1·55 foot-candles, in good agreement with Mr. Trotter's more expeditious method.

Everyone would agree with Mr. Gaster in insisting upon the importance of accuracy in polar curves published to illustrated the performance of lamps and fittings. A summation curve ought to be shown as well, as the polar curve, even though correctly drawn, is apt to be misleading.

Mr. Darch and others would find full information as to the Kennelly construction in the references given in the paper, but as these may not be generally accessible, Mr. Dow has promised to deal with this and other matters in a forthcoming number of the journal.

The physiological effect of light in the eye was also referred to by Mr. Lovibond, but this important question was not included in the scope of the paper.

It was gratifying to hear from Mr. Clark that he was using the flux of light method wherever possible, as the estimation of average illumination, and the effect of finite luminous areas were much better dealt with on this basis. The suggestion as to the collection of data was a good one, and such a collection, if of sufficient extent and properly handled, should yield reliable constants for design in illumination. Many of the curves of comparison of calculated and observed illumination values showed clearly that it was not the method of calculation, but the values of the constants assumed that prevented the agreement between them from being even better than it was.

It is curious that the discrepancies in Fig. 16 should have been selected for criticism, as that example was quoted on account of the surprisingly good agreement between observation and calculation. No doubt a small part of the difference could have been eliminated by applying the correction for a disc, but it was felt to be hardly worth while, as it only amounts to 1 per cent. for a diffusing disc whose diameter is $\frac{1}{5}$ of the distance to the bench. Both in this case and in the example quoted by Mr. Clark there is probably some focusing action due to the deep reflector.

In the class-room of Fig. 14, the whole area of the room was taken for the determination of the mean horizontal illumination, as was done in every other case. Its value was estimated approximately from the calculated values at the points given in Table VIII. by weighting each point with a due proportion of the floor area. The result is rather an overestimate, as a careful check by taking zonal areas round each lamp gives 3·4 foot-candles as the value. This makes the figure of 60 per cent. rather high for the utilisation factor. Of course the diversity coefficient can be made smaller by limiting the area, but this limitation would still further reduce the utilisation factor.

The coefficients of reflection used in the calculations of example 7, about which Mr. Ritchie made inquiry, were those given by Dr. L. Bloch, as 66·5 per cent. for limewash, and the same figure for limewash of a light chrome yellow colour, the surfaces being new and clean. Under

working conditions no doubt these would be considerably diminished. It would probably be safer to neglect the reflecting power of the boarded portion of an ordinary factory saw-tooth roof, when predetermining the illumination underneath. In example 4 the readings were taken some days after the installation was put in, so that a deposit of dust and dirt on the shades might account for the apparent absence of any effect of reflection from the walls. In this connection Mr. Ritchie has very properly pointed out that there are two distinct kinds of ageing, one due to the loss of efficiency of the source itself, and the other due to accumulation of dust and dirt on the surrounding reflecting surfaces. Which of these would be the greater, would evidently depend on the kind of illuminant used.

Mr. Mackinney has referred to the Sumpner formula for repeated reflection as being of little use for ordinary interiors, which is no doubt true, but it is at the present time the only generalised statement we have dealing with the question of interior reflection. The problem that presents itself is to extend the formula to apply to the case of a room with non-reflecting walls and floor.

The figures given by Mr. Willis are interesting as showing the effect of the elimination of one of the ageing factors mentioned above. Of course this was only secured by constant care and attention, a point also insisted upon by Mr. Eck.

Mr. Dow has given another calculation for an indirect installation which again shows the value of the flux of light method in handling these problems. The information to be gained from tests made on standard surfaces could only be of value if the suggestion of Mr. Wallis Jones, that surfaces should be prepared in accordance with some well-known standard colour scheme, could be carried out.

The explanation put forward by Mr. Harvey-Gooch of the shape of Clewell's curves being due to the superposition of two curves of deterioration, one giving a very slow drop due to dust and dirt, the other giving a much longer and more sudden drop due to ageing of the source, does not account for the much greater total drop in about the same period of operation when the location is altered, as is shown by the two curves given.

THE KENNELLY GRAPHICAL CONSTRUCTION FOR OBTAINING MEAN SPHERICAL CANDLE-POWER.

AT the request of several members of the Society we are abstracting Dr. Kennelly's paper giving this construction, which was published by the American Illuminating Engineering Society in 1908.*

The following is the description of the construction :—

The new diagram can, perhaps, best be explained by referring to an actual example, Fig. 1. The curve O E F G K L represents the polar distribution curve of a particular luminous source occupying the virtual point O. This curve has been taken as a segment of a circle, with diameter O G taken as unity, and depressed 45° below the horizontal plane O H. The reason for selecting such a circular polar curve is that its mean spherical intensity is easily computed, in the manner set forth in the Appendix. It follows from the computation that the mean spherical intensity of this polar curve, assumed as uniform in azimuth about the vertical VV′, is 0·593 in terms of the intensity O G as unity. The new construction is as follows :

First select the number of zones to be employed in altitude. In Fig. 1 there are three such zones, of 45° each. The upper hemisphere has one 45° zone, H O B. The lower hemisphere has two 45° zones, i.e., H O G and G O V′. Mark off the middle angular points of the zones, viz.,

* Trans. Am. Illum. Eng. Soc, April 1908, p. 243.

O E, O F, and O K, which will be at elevations of $+22\frac{1}{2}°$, $-22\frac{1}{2}°$, and $-67\frac{1}{2}°$ respectively.

Commence, say, in the upper hemisphere. With centre O and the radius O E of the midzone, draw the arc A E B through an angle of 45°. Draw the line O B to the end of this arc.

Turning next to the lower hemisphere, describe an arc with centre O and the radius O F of the first midzone, to M, through 45°. Connect O and M by the line O M. Measure back along M O a distance equal to the radius O K of the second midzone, and mark off this distance at a point which shall serve as the centre of the next arc. It happens in this particular case that the new point coincides with the point O. With that point as centre, and with radius O M, draw another 45° arc from M to V′; so that O V′ makes an angle of 45° with O G, and also 90° with O H. Draw the line O V′.

Take any convenient point, such as H, on the horizontal line, and draw a perpendicular Q Q′ through the same, parallel to V V′. In some cases it may be convenient to employ V V′ itself, without erecting the new vertical Q Q′. Project the terminal points B and V′ horizontally upon Q Q′. Bisect the intercept Q Q′ in R. Then either the distance Q R or Q′ R will be the mean spherical intensity of the luminous source, to a degree of approximation depending upon the accuracy of the graphical construction and upon the number of zones selected. In Fig. 1 the distance Q′ R is 0·598 if O G is unity. It is easy to show that if the geometrical construction were made without error, and Q′ R were scaled correctly, the length would be 0·5973 as far as four significant figures. Comparing the actually measured length 0·598 with the theoretically deduced value of 0·5933, given in the Appendix, it will be seen that in this instance, with only three zones, the result of the graphic construction is correct within 1 %. As a general rule, however, 45° zones may introduce an error of two or three per cent. The apparent spherical reduction factor = Q′ R/O h.

Moreover, since the total flux of light emitted by a virtual point source is 4π times its mean spherical intensity, it follows that if a circle were drawn with radius Q Q′, the length of the circumference would be equal to the total luminous flux emitted by the source O. Further, if the polar intensities are scaled in candle-power, then 2π Q Q^1, or 7·52 × O G will be the total luminous

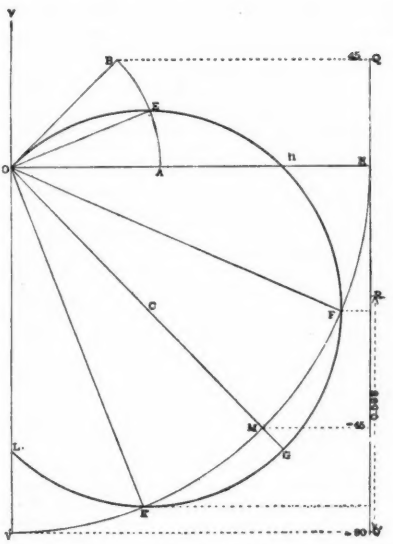


FIG. 1.—New Diagram of Simple Circular Polar Curve depressed diametrically 45°. Rectified by 45° zones.

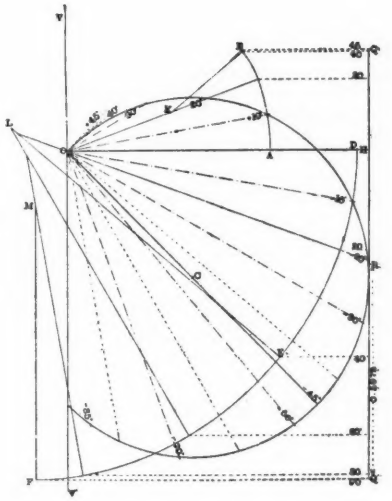


FIG. 2.—The same Polar Curve rectified by 20° zones.

flux in candle-lumens. If the polar intensities are scaled in hefners, then 2π Q Q^1 will be the total luminous flux in hefner-lumens. Further, the total flux in the upper hemisphere will be 2π Q H lumens, and the total flux in the lower hemisphere will be 2π H Q^1 lumens. If we should desire to know how much flux is emitted between the horizontal plane and the depression-angle 45°, we should measure H—45, and multiply by 2π. Similarly 2π times the distance along Q Q^1 between any two projected points is equal to the total flux emitted in the angular zone between the corresponding points in the polar curve. Or, expressing the same condition in another way, the distance along Q Q^1 between any two projected points is numerically equal to the flux in lumens per radian of azimuth, emitted in the corresponding zone on the polar diagram.

Again, H Q is the mean upper hemispherical intensity, H Q^1 is the mean lower hemispherical intensity, and the mean spherical intensity is seen to be the arithmetical mean of these two hemispherical intensities.

Fig. 2 shows the same construction except that zones at intervals of 20° instead of 45° have been taken. In practice 20° zones are recommended for reliable work, and in many cases 30° zones are sufficiently small.

The following is Dr. Kennelly's explanation of the theory of the method :—

Theory of the Method.

The mean spherical intensity of a luminous source having equal intensities in azimuth and occupying a virtual point is

$$I_m = \tfrac{1}{2}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} I_\theta \cos\theta \, d\theta \qquad \text{candle-power or hefners (1)}$$

where I_θ is the luminous intensity at the elevation θ. Let there be n equal zones each of $\frac{\pi}{n}$ radians. Then the above equation becomes :

$$2I_m = \int_{-\frac{\pi}{2}}^{-\frac{\pi}{2}+\frac{\pi}{n}} I_\theta \cos\theta \, d\theta + \int_{-\frac{\pi}{2}+\frac{\pi}{n}}^{-\frac{\pi}{2}+\frac{2\pi}{n}} I_\theta \cos\theta \, d\theta + \ldots$$

$$+ \int_{\frac{\pi}{2}-\frac{\pi}{n}}^{\frac{\pi}{2}} I_\theta \cos\theta \, d\theta + \int_{\frac{\pi}{2}-\frac{2\pi}{n}}^{\frac{\pi}{2}-\frac{\pi}{n}} I_\theta \cos\theta \, d\theta \qquad \text{hefners (2)}$$

In each of the above n terms, I_θ can differ but little from its value at the midzone. We can therefore write without much error :

$$2I_m \cong I \int_{-\frac{\pi}{2}+\frac{\pi}{2n}}^{-\frac{\pi}{2}+\frac{\pi}{n}} \cos\theta \, d\theta + I \int_{-\frac{\pi}{2}+\frac{3\pi}{2n}}^{-\frac{\pi}{2}+\frac{2\pi}{n}} \cos\theta \, d\theta + \ldots$$

$$+ I \int_{\frac{\pi}{2}-\frac{3\pi}{2n}}^{\frac{\pi}{2}-\frac{\pi}{n}} \cos\theta \, d\theta + I \int_{\frac{\pi}{2}-\frac{\pi}{2n}}^{\frac{\pi}{2}} \cos\theta \, d\theta \qquad \text{hefners (3).}$$

It will be seen by inspection that the construction in Figs. 1—4 makes Q Q^1 = $2I_m$ and that the projection of each arc in the involute curve on the line Q Q^1 corresponds to one term on the right-hand side of (3).

The construction of the involute curve may be seen to express the relation

$$s \cong \int_0^{\frac{\pi}{2}} I_\theta \, d\theta \qquad \text{units of length}$$

and

$$\int_{-\frac{\pi}{2}}^{0} I_\theta \, d\theta \qquad \text{units of length}$$

in the upper and lower hemispheres respectively.

When the zones are taken of 20°, it is advantageous to select as their mid-angular elevations +80°, +60°, +40°, +20°, +0°, —20°, —40°, —60°, —80°. This leaves no uncompleted arc at either terminus, and it avoids any discontinuity in the involute curve at the horizontal line. The first arc is drawn from +10° to —10° with the radius equal to the mean horizontal intensity.

THE LIGHTING OF RAILWAY CARRIAGES AND OTHER PUBLIC VEHICLES.

Proceedings at a Meeting of The Illuminating Engineering Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, LONDON, on Tuesday, April 7th, 1914.

A MEETING of the Society took place on Tuesday, April 7th, the chair being taken by Mr. L. GASTER, in the unavoidable absence of Mr. F. W. GOODENOUGH (Chairman of Council). The Minutes of the last meeting having been taken as read, the Hon. Asst. Secretary announced the names of applicants for membership in the usual way.

THE CHAIRMAN then called upon Mr. E. Kilburn Scott to open the discussion on **The Lighting of Railway Carriages and other Public Vehicles.**

A discussion then ensued in which Mr. J. S. DOW, Prof. J. T. MORRIS, Mr. R. A. IVES, Mr. V. H. MACKINNEY, Mr. E. STYLES, Mr. G. CAMPBELL, and Mr. R. C. BUSSELL took part.

Mr. E. KILBURN SCOTT briefly replied. A vote of thanks was accorded to him for opening the discussion, and also to the engineers of the various railway companies, who had contributed to the success of the evening by granting facilities for tests and photographs to be taken.

In conclusion THE CHAIRMAN announced that the **Annual Meeting** would take place on **Thursday, May 21st,** when, after the transaction of formal business, a paper would be read by **Mr. A. P. Trotter** on the **Nomenclature and Definitions of Photometric Quantities.**

NEW MEMBERS OF THE SOCIETY.

THE names of applicants for membership read out at the previous meeting on March 17th* were read again at the last meeting on April 7th, and these gentlemen were formally declared members of the Society.

In addition the names of the following gentlemen have been duly submitted and approved by the Council and were also read out by the Hon. Secretary at the last meeting :—

Keable, E. F. Assoc. Mem. Inst. Gas Engineers	Assistant Engineer and Manager and Inspector of Public Lighting, Gas Works, SOUTHTOWN, GREAT YARMOUTH.
Legg, F. G. I.	Chief Engineer to Messrs. Spiers & Pond, Ltd., 35, New Bridge Street, Ludgate, E.C.; White House, PURLEY DOWNS, Surrey.
Martin, W. G.	Engineer Service Department, National Ray Reflector Co., 235, W. Jackson Boulevard, CHICAGO, Ill., U.S.A.
Mitchley, J. W.	Assistant Engineer and Manager to the King's Lynn Gas Co., 20, St. James Street, KING'S LYNN.
Musgrave, Major H.	Royal Flying Corps (Military Wing), SOUTH FARNBOROUGH.

* *Illum. Eng.*, April, 1914, p. 187.

OFFICIAL ANNOUNCEMENT OF ANNUAL MEETING.

The Annual Meeting will take place at the House of the Royal Society of Arts, 18, John Street, Adelphi, LONDON, W., at **7.30 p.m.,** on **Thursday, May 21st.**

After the transaction of formal business a paper will be presented by **Mr. A. P. Trotter** on **"The Nomenclature and Definitions of Photometric Quantities."**

THE LIGHTING OF RAILWAY CARRIAGES AND OTHER PUBLIC VEHICLES.

By E. Kilburn Scott.

(Opening remarks in a discussion at the Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m., on Tuesday, April 7th, 1914.)

In common with many whose eyesight is not of the best, and who have to use railway trains and public vehicles every day, the writer has had occasion to observe closely the lighting of such vehicles. It is pleasing to be able to say that during the last ten years there has been a marked improvement, and yet all will agree that much has yet to be done.

These notes are intended to serve as an introduction to a discussion on the subject.

The object is to consider questions relating to the arrangements of lights in carriages, their position, the method of shading, and the illumination produced. Incidentally such matters as the supply of gas and the generation of electricity will be referred to.

Quite a number of illuminants have been and still are used for carriage and vehicle lighting. They are :—

(*a*) Oil lamps.
(*b*) Compressed gas.
(*c*) Oil gas.
(*d*) Acetylene gas.
(*e*) Electric light.

The introduction of the inverted mantle, with its economical consumption, compact form, and improved durability, did a great deal for gas lighting. Similarly the metal filament incandescent lamp has made electric lighting practicable where otherwise it could not have been used. An important factor in electric lighting has been the great advance in methods of generation and control. These problems do not lie strictly within the scope of our discussion, but they have had a vital influence. There have been several recent papers on the subject.* It may also be recalled that about two years ago a paper was read before this Society on the Lighting of Railway Stations and Goods Yards.†

Candle-power.

In modern carriages the illumination is much in advance of what it was a few years ago. In gas-lighted railway carriages, the mantles usually adopted are rated at about 30 c.p., whereas electric incandescent lamps are usually 10 c.p. lamps at 24 volts, three of these being not infrequently used for an ordinary third-class carriage. When the electricity has to be generated on the train the size, output and initial cost of the plant, especially the battery, sets a limit to the light employed.

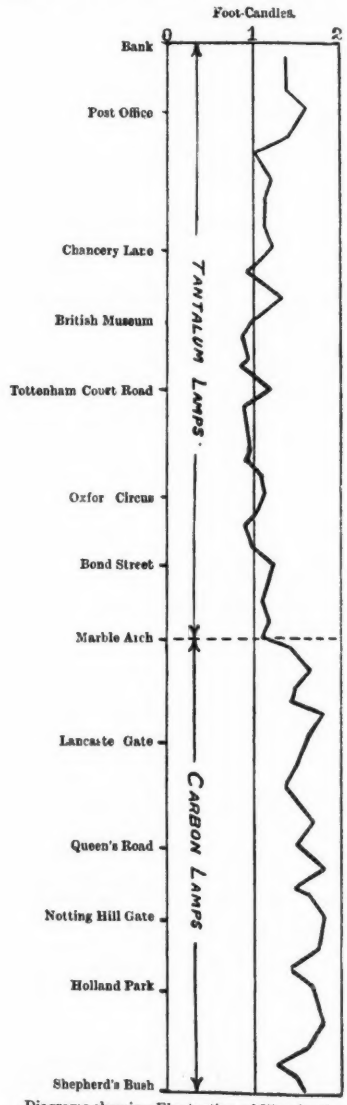
But in trams and tube railway carriages fed from an external supply, lamps of much higher candle-power can be employed, and we find that in these circumstances the illumination is considerably higher than in steam-driven trains. The conditions in petrol-driven vehicles, motor-cars and motor-buses approach more closely those in steam-driven trains since the electricity has to be generated on the carriage. In the latter vehicles, oil and acetylene are still used.

One advantage of self-contained systems of lighting is the comparative constancy of the light. On tramways and tubes the fluctuations may be trying to the eyes. In the earlier days of tubes the diminution of pressure sometimes brought the lights down almost to a red glow. At the present time improved methods of distribution and larger plant capacity have partially remedied these troubles. But on some of the railways there is still a decided diminution in light as the train is starting up and a heavier current is taken. This point was investigated by Prof. J. T. Morris some years

* *Electric Lighting of Railway Trains : The Brake-Vehicle Method.* By Roger T. Smith, Institution of Civil Engineers, Nov., 1911. *Electric Train Lighting.* By N. Ferguson. Paper before the Institution of Electrical Engineers, January, 1914.—*Electric Lighting of Steam-driven Trains.* By E. Kilburn Scott. *Journal of the Society of Engineers,* January, 1914.

† *Illum Eng* Lond., January, 1912.

ago, and he gave an interesting diagram showing the variation in illumination from station to station.* (See Fig. 1.)



Diagrams showing Fluctuation of Illumination during a journey on the Central London Railway, June 14, 1910.

(Prof. J. T. Morris.)

FIG. 1.

* *Architect and Contract Reporter*, 1910.

The total extinction of the lights at intervals in the case of certain London trams when travelling over the points is well known. It is a discomfort to travellers, particularly those whose eyes are weak.

A difficulty which any illuminant used for vehicle lighting has to meet is the effect of vibration. In the old coaching days, the swaying of the vehicle did not affect the light of the oil lamps very materially; but in vehicles of to-day it is not *swaying* that we have to put up with but an intense *vibration* or *tremor*. We are so accustomed to the tremors in the cities that we hardly notice them, but people who spend their lives in the country are invariably struck thereby when they visit the cities, especially London. In the early days of incandescent gas lighting, this vibration proved an obstacle to the use of mantles, and it was not until the introduction of the inverted mantle and improved methods of suspension that the incandescent gas system became feasible for railways.

When metal filament lamps were first introduced the fragility of the wire was a drawback. (A curious fact mentioned by one railway engineer was that the lamps seemed to give way at night whilst the carriages were standing. On taking out a train in the morning the driver would find that quite a number of filaments were broken.)

The manufacture of the filament has, however, been rapidly improved, and at the present time metal filament lamps are used on most of the underground railways, five 100-volt lamps being run in series.

For steam-train lighting the voltage is only 24 volts, so that thicker filaments are possible, which is, of course, a distinct advantage. The 10 c.p. 24-volt lamps usually employed consume 1·3 watts per candle-power and have an average life of about 900 hours.

Regarding the number of hours' run by carbon and by metal filament lamps it has been stated that, in order to make it worth while to use the more expensive lamps, the average life should be over 2,000 hours. In all such cases the cost of lamps, life obtainable, and price at which electricity can be provided have to be considered. Companies running electric trains have usually ample power available, and the higher efficiency of

the metal filament lamps is not such an important consideration as it is on a steam-driven train where each carriage carries its own generating plant.

Position of Lights.

On the question of the positions of lights in carriages and the method of shading, a distinction must be drawn between a railway carriage which is divided into box compartments and a long saloon carriage or a tramcar. The most usual plan is light from overhead, and formerly there used to be merely a single oil lamp in the centre of the roof. Later, central gas lamps were substituted, and now, with electricity, there are usually several ceiling lights. When only a single source is used some of the passengers receive light from an inconvenient angle. It is much better to space

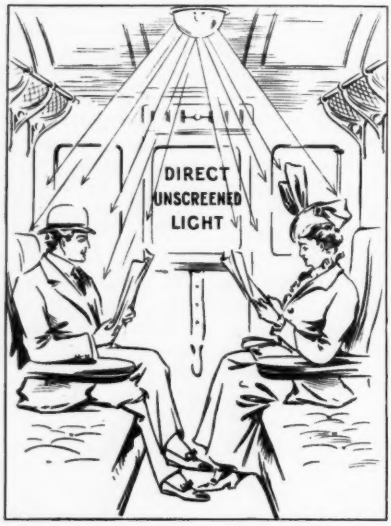


FIG. 2.—DIRECT UNSCREENED CENTRE LIGHT.

Rays strike the newspapers at an inconvenient oblique angle, and the glare of the bare lamp is distressing to the eyes when the passenger glances upward.

several lights over the roof of the compartment, and electricity lends itself to this method exceedingly well. In the discussion on Mr. Roger T. Smith's paper before the Civil Engineers Mr. Henry Fowler mentioned a saloon on the Paris-Orleans railway which had seats for 26 passengers, and was equipped with about 125 electric lamps of small candle-power set out in the roof like a constellation.

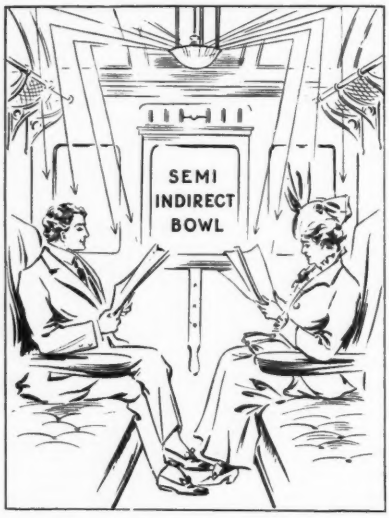


FIG. 3.—SEMI-INDIRECT LIGHT.

Reflected rays from the ceiling strike the paper at all angles, and the bare source is screened from the eye.

The roof is naturally the most convenient place to place the lights, and if there are several of them and the ceiling is itself white in colour so as to diffuse the rays, a moderately good illumination is obtained. As shown in Fig. 2, direct light, as distinguished from the reflected light, is not convenient, because the rays strike a newspaper, held in the customary position, at such an oblique angle. Although the light is directly out of the horizontal range of vision, travellers catch the light directly in their eyes whenever they look upwards—a somewhat usual attitude for a man lost in thought.

It would be interesting to hear from those present whether any experiments in carriages of this kind have been made with semi-indirect lighting, as shown in Fig. 3. By this method the light is reflected in many different directions, and the chief objection to the ceiling light, namely, rays falling directly at an inconvenient angle, is removed.

With a white ceiling and good diffusing globes, this method may be recommended. The engineers connected with railways and traffic companies are usually quite aware of the desirability of getting a soft light and using proper methods of shading, but the directorates apparently require to be educated. The latter usually travel in first-class saloon carriages where the lighting is good. It is the third-class that most requires attention.

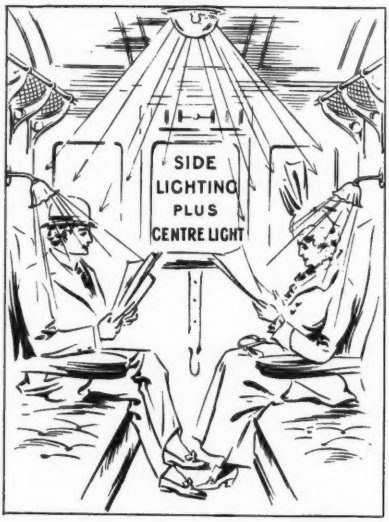


FIG. 4.—COMBINATION SIDE AND CENTRAL LIGHT.

The centre light provides general illumination. The local shaded lights enable passengers to read in comfort.

From the standpoint of reading there is much to be said for brackets on the walls, as the light then comes over the reader's shoulders as in Fig. 4. Mr. Henry Fowler has spoken approvingly of the lighting arrangements on the German state railways, where each lamp is mounted in a concave reflector so arranged as to prevent the light shining into the eyes of people opposite. If the lights are adequately shaded, however, so as to prevent glare to persons on opposite seats, then the top of the carriage may be somewhat dark. A combination of side and central lighting is perhaps the best compromise.

Another method of carriage lighting that might be adopted, possibly in conjunction with a certain amount of bracket lighting, is the indirect cornice system with tubular lamps running down either side of the carriage. Railway compartments usually have curved ceilings immediately over the doors, which are convenient for this variety of lighting; the writer understands that tubular lighting is in use on some Great Northern trains.

Glare.

A good deal might no doubt be written on the special arrangements in royal trains, dining cars, &c. It is interesting to note that at one time a royal saloon in India was used by Lord Curzon, and he complained that he could not read. By shading the central cluster with a suitable enamelled reflector, the illumination was brought up to a satisfactory value. This shows how important it is that either the roof should be painted white or lamps should be provided with suitable reflectors.

The sombre tints habitually used for the cushions in railway carriages in this country absorb a good deal of light, and it would be much better to use somewhat lighter tints, as is more general in other lands, particularly in warm climates.

A light ceiling makes the glare from an unshaded light much less noticeable. A bright object, seen against a light background, does not appear nearly so dazzling as it would do if the surroundings were black, for glare is largely a matter of contrast.

On the other hand, one would not recommend that the surroundings should be all dead white, or even all a light colour, as such monotony is apparently trying both to the eye and the mind. The effect on Arctic explorers of a monotonous white landscape is well known.

The white of a ceiling should be a *dead* white, not a *shiny* white. Personally the writer would also prefer that all shiny woodwork, &c., be avoided. The form of glare consisting of reflections of lamps on shiny surfaces is very distracting. It recalls to the writer the small boy's trick with the sun reflected from a mirror. No doubt the railway

companies prefer the shiny surfaces because they can be more easily cleaned.

In tube railway carriages and tramcars the almost universal system in this country is to have two rows of bare lamps, studded direct on the ceiling. Perhaps "strap-hangers" make the use of shades undesirable.

But the time is surely coming when passengers will no longer be satisfied by rows of glaring lights right in the line of vision. Several papers on this subject have recently appeared in the United States, and it would appear that the engineers there are coming to the conclusion that suitable methods of shading, besides giving much better effect, are also economical.

A comparison was recently made by Mr. Hibben* between bare tungsten lamps, and tungsten lamps with reflectors. He found that by the use of appropriate reflectors, and lamps of somewhat higher candle-power than those previously employed but spaced wider apart, a reduction in energy consumption from 1·62 to 1·31 watts per square foot was achieved. Nevertheless, the reading illumination was increased from 2·71 to 3·24 foot-candles.

TABLE I.—STREET RAILWAY LIGHTING.

Illumination Data—Bare *versus* Shaded Tungsten Lamps.

(Hibben, Trans. Am.I.E.S. 1913.)

	Bare Tungsten lamps.	Shaded Tungsten lamps.
No. of lamps ..	8·0	3·0
Candle-power per lamp	30·0	75·0
Watts per lamp ..	39·0	84·3
Total watts	312·0	253·0
Total generated lumens	2560·0	2142·0
Area car floor ..	194·0	194·0
Watts per square foot	1·62	1·31
Average foot-candles	2·71	3·24
Useful lumens ..	525·0	628·0
Utilization factor ..	22·08%	29·30%
Relative efficiency ..	75%	100%

In Toledo, experiments have been made with several different systems, including the use of shaded lamps on either side of the carriage, and the use of central semi-indirect lighting. It is said that the latter system is proving very popular with the general public.* It would be of interest to know if any similar experiments are being made in this country.

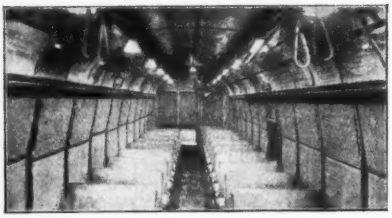


FIG. 5.—Showing use of Reflectors on side lights, in cars in Toledo, U.S.A.

Similar problems occur in other public vehicles and the writer is glad to see that a good deal of enterprise is being shown in the lighting of motor-buses, particularly by Mr. Clarkson on those of the National Steam Car Company. The

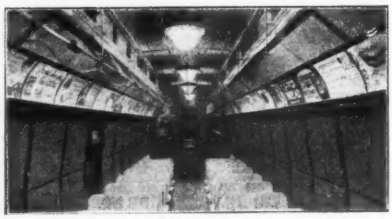


FIG. 6.—Central semi-indirect lighting in use in cars in Toledo, U.S.A.

recent introduction of lights studded on the ceiling, instead of merely at the extremities of the vehicle, makes reading feasible and adds greatly to the comfort of passengers.

Standards of Illumination.

From the existing data it is somewhat difficult to draw conclusions, because observers have used different methods of measurements. Mr. Roger T. Smith, for instance, prefers to make measurements in a plane 4 ft. above the floor, which is

* Trans. Am. Illum. Soc., December, 1913.

**Electric Railway Journal*, November 8th, 1913.

the position of the eyes of a seated passenger. Others prefer to measure the horizontal illumination on the passenger's knees, which is a convenient position to hold a photometer, and is perhaps more suitable in low carriages, where a plane 4 ft. up might be very near the lamps used.

Table II., taken from a recent address by Mr. P. S. Millar before the American Illuminating Engineering Society, shows the historical development of the standard of illumination in the United States.

TABLE II.—DAY COACH LIGHTING.

Installed during	Description of Illuminants.	Average horizontal foot-candles 30 ins. above floor.
1850-1875 ..	Oil lamps—	
	2 wicks feeding one flame	0·5
	Annular wick ..	1·0
1875-1900 ..	Pintsch gas—	
	4 fish-tail flames ..	1·5
	4-mantle cluster ..	1·65
1880-1900 ..	Carburetted gasoline—	
	Centre draught ..	1·3
1900 to date	Electric—	
	50-watt opal-tip lamps and flat reflectors ..	1·4
	50-watt clear lamps and satin finish bowl reflectors ..	3·0

Speaking generally, it would appear that there is now little difficulty in obtaining 2 foot-candles, and as this is the minimum prescribed by the Joint Committee on School and Library Lighting, the writer considers that the illumination of public vehicles should not be less. In the near future companies will doubtless prefer to keep *well above* this figure, for it is now becoming recognised that it is well worth while for a company to cater for the convenience of passengers in this way. People habitually read when travelling and the conditions of illumination provided influence a passenger in selecting his route, especially if he s bound on a long journey. This preference of people can be seen at any railway station by the way which they pick out the well-lighted carriages.

Mr. Aspinall, of the Lancashire and Yorkshire Railway, has stated that it costs roughly four times as much to heat a carriage as to light it. Even with the best lighting the cost is but a trifling percentage of the total running cost per mile, and this is amply repaid by the gain in patronage from the public. Good lighting reacts in several other ways—for example, shabbiness at once becomes apparent under a good light, so the companies are obliged to keep the carriages in better condition.

The public now follow any changes in lighting much more closely than they did, and their occasional criticism, even if sometimes mistaken or capricious, shows the value they now attach to good illumination.

It is to be hoped that this discussion will be helpful in bringing about agreement on the characteristics of good carriage lighting; and that, as in the case of school and library lighting, the Society will be instrumental in suggesting recommendations which will be adopted by those responsible for public transport.

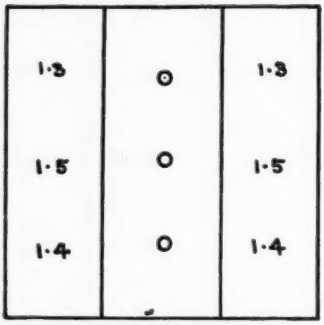
The CHAIRMAN remarked that lighting is now playing a much more important part in connection with vehicles than in the past. It is interesting to see how the subject has been parcelled out among many different departments of various railways. For example, it seems to be dealt with mainly by the Carriage and Locomotive Department, but in some cases, particularly where the electrical engineer has devoted special attention to the subject, he acts as adviser. It is rare to find the gas lighting and electric lighting carried out by the same expert. The two systems are usually considered by quite different departments.

Similarly, the lighting of carriages is differentiated from the illumination of platforms, goods yards, &c. He understood that on the Underground Railways the carriage lighting rests with the Mechanical Engineer, while the station lighting is carried out by the Civil Engineer and his staff.

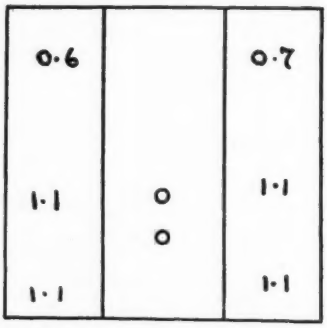
He might mention, however, that some railways had established a special lighting department dealing with illumination by gas and electricity and oil. But even in such cases, it appeared, their work is confined to outside lighting, and the illumination of carriages is dealt with by an entirely separate department. He ventured to suggest that the time is ripe for a special department to consider all problems of illumination on railways. Considering the vast sums of money now spent on lighting, he thought such a step would be fully justified.

Mr. J. S. Dow explained that these tests had been made at somewhat short notice in order to supplement Mr. Kilburn Scott's contribution. The tests were not put forward as exhaustive, but might be of interest as showing the conditions met with in typical coaches to-day. It occurred to him that this was a good opportunity to collect some impartial data on carriage lighting by various illuminants for the benefit of the Society, and he hoped that this record of existing conditions would be of value to members for future reference

As Mr. Kilburn Scott had remarked, it was not easy to devise a method of measurement which would give exactly the reading illumination the passenger would enjoy. Much depended upon the angle at which the book or paper was held, the height of the carriage, the position of lights in carriages, &c. He had come to the conclusion that the best compromise in these tests would be to measure in a horizontal plane at the level of the passenger's knees, which would represent about the lowest illumination likely to be received on a newspaper. This method also gave results not far removed from those obtained on a horizontal plane 2½ ft. from the floor,



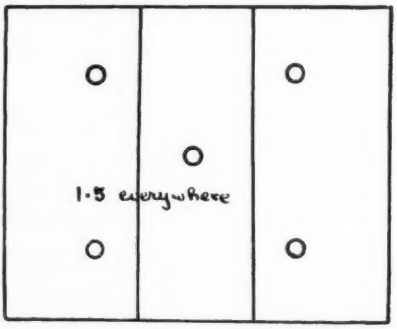
3rd class compartment (modern system).



3rd class compartment (old system).

FIG. 1.—Great Western Railway (Electrically lighted carriages).

(The figures indicate the illumination in ft.-candles, measured in horizontal plan on passengers' knees.)



1st class carriage (modern system).

which had been adopted by Prof. Morris in this country and by some authorities in the United States.

During his visits he had endeavoured to ascertain what distinction was made between the lighting of various classes of carriages.

Mr. Dow then showed several illustrations of ordinary carriage lighting on the Great Western Railway. The system of electric lighting formerly employed was to use two roof lights spaced near together. In these circumstances he found that an illumination varying between 0·7 and 1·1 foot-candles was obtained. Mr. Roger T. Smith had recently pointed out that a much better distribution of light was obtained by spacing three lights (10 c.p.) down the centre of the compartment. With this arrangement he (Mr. Dow) found a practically uniform illumination of 1·4 foot-candles. In 1st class carriages five lights in prismatic globes were used, but owing to the somewhat large dimensions of the compartment the illumination was substantially the same as in the 3rd class.

Some measurements were also taken in gas-lighted coaches on this railway. For these, burners rated at 25 c.p. were

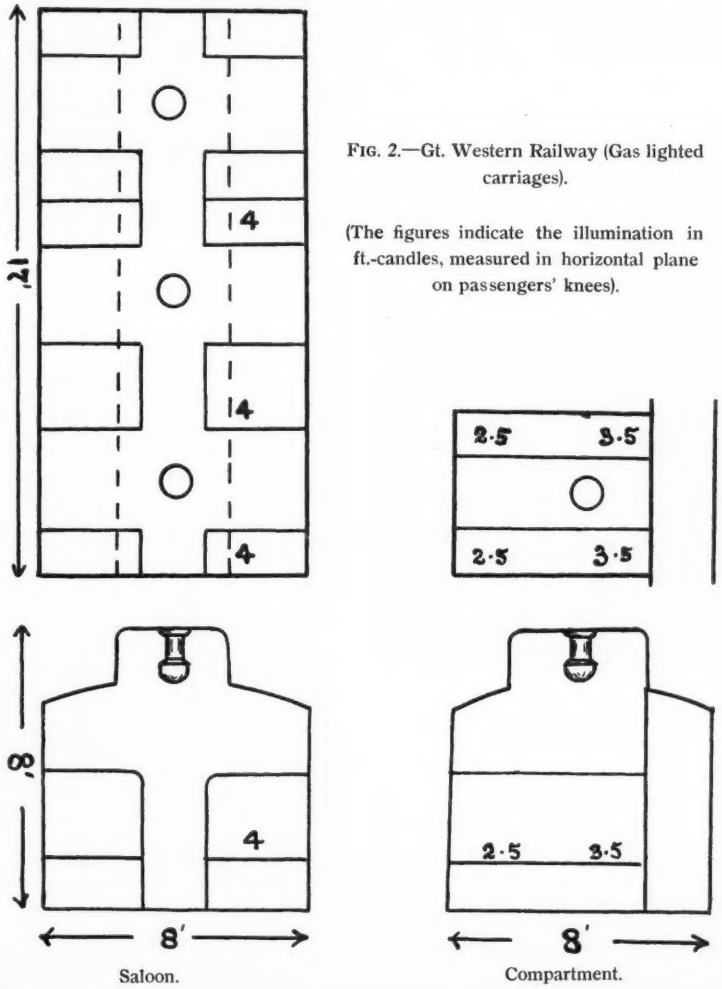


FIG. 2.—Gt. Western Railway (Gas lighted carriages).

(The figures indicate the illumination in ft.-candles, measured in horizontal plane on passengers' knees).

used, a single burner being mounted on the roof of the carriage, and with the arrangement prevailing in an ordinary compartment the illumination was 2·5—3·5 foot-candles. The lack of uniformity was due mainly to the light being concentrated in a single source. In saloons, where a number of such lights were used, it was much more even.

On the Gt. Eastern Railway the usual practice was to use overhead lighting (except in dining cars where bracket lights over each table are provided). In first-classes a three-light electrolier, carrying 16 c.p. lamps, was used, in third-classes a similar fitting with two lights. Gas-lighted carriages were furnished with a single central burner rated at 25 c.p.

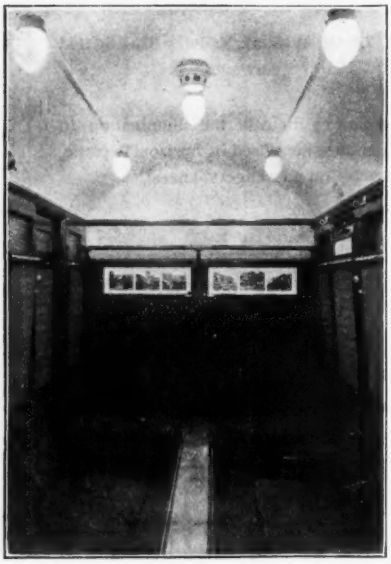


FIG. 3.—Electrically lighted saloon (G.W. Rly.). Tungsten lamps in etched glass globes. 2·5–2·7 ft.-candles.

Mr. Warren, of the Locomotive and Carriage Department at Eastleigh, had kindly given some particulars of the lighting in main and suburban carriages on the L. & S.W. Rly.; 32 c.p. per compartment was usual in electrically-lighted carriages. However, on certain special carriages on the suburban lines

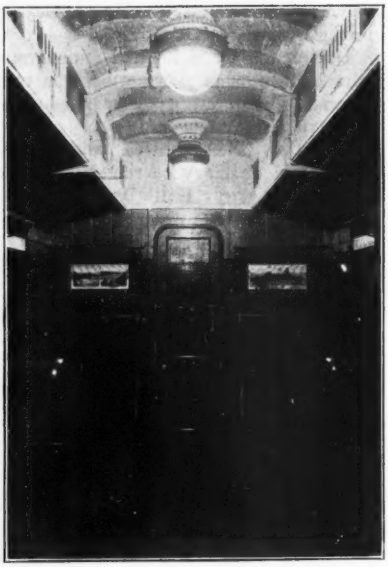


FIG. 4.—Gas lighted saloon (G. W. Rly.) Central gas lamps; 4 ft.-candles.

FIG. 5.—Saloon on Southend Express (Midland Rly). Central lights, supplemented by brackets.

as much as 60 c.p. per compartment was provided, owing chiefly to the use of special bracket lights for reading. In gas-lighted carriages burners rated at 40 c.p. were used.

As illustrating the progress towards improved illumination in recent years he would like to give the following table kindly furnished by Mr. Warren, showing practice of the L. & S.W. Rly. from 1907—1913 :—

L.S.W. RAILWAY SUBURBAN STOCK.

Year.	1st class compartment.	2nd class compartment.	3rd class compartment.
1907 ..	20 c.p.	16 c.p.	16 c.p.
1908 ..	24 „	20 „	20 „
1909 ..	24 „	24 „	24 „
1913 ..	32 „	32 „	32 „

STEAM RAILWAYS.

Railway and Type of Coach.	Method of Lighting.	Illumination.
		Ft.-candles (horizontal), level of passengers' knees.
GT. WESTERN RY.	*Electric.*	
3rd class compartment	(1) *Old System :* Two 10 c.p. lamps in one fitting on roof, equipped with opal shades	0·7—1·1
	(2) *Modern System :* Three 10 c.p. lamps in etched glass globes distributed on roof ..	1·4—1·5
1st class compartment	(3) Five 10 c.p. lamps in prismatic glass globes distributed on roof	1·5
	Gas.	
1st and 3rd class compartments	Roof light, mantle rated at 25 c.p., in clear globe	2·5—3·5
	Electric.	
Saloon	Eight 10 c.p. lamps in etched glass globes distributed on ceiling	2·5—2·7
	Gas.	
Saloon	Three burners rated at 25 c.p. in clear globes down centre	4
LON. & S. WESTERN RY.	*Gas.*	
Main Line 1st, 2nd, and 3rd class compartments	Inverted mantle rated at 40 c.p. in clear glass globe, central in roof	—
	Electric.	
1st, 2nd, and 3rd class compartments	Lamps in central clear glass basin giving total of 32 c.p.	—
Main Line Dining Car	Five special diffusing globes, each containing three 16 c.p. lamps. Brackets, each containing one 12 c.p. half-frosted lamp with Langham shade over the dining tables ..	—
Special 1st class Suburban carriage	Central roof light, with one 12 c.p. lamp and Langham shade. Four brackets over seats, each containing 12 c.p. lamps in Langham shade	—
GT. EASTERN RY.	*Gas.*	
All classes.	Central burner rated at 25 c.p. in clear glass basin	—
	Electric.	
1st class	Electrolier carrying three 16 c.p. lamps in opal shades	—
3rd class	Similar arrangement with two lights ..	—
MIDLAND RY.	*Electric.*	
(Southend Express). Saloon (1st class)	The carriages partitioned into two. Each section contains two central frosted glass bowls, each containing three 10 c.p. lamps. There are also six brackets containing similar lamps	3½—4. ft.-c.
	N.B.—In electrically lighted coaches metal filament lamps are used.	

The lighting of saloons and dining cars is naturally somewhat different from that in ordinary carriages. Illustrations are given of saloons lighted respectively by gas and electricity on the Great Western Railway and on the Southend express controlled by the Midland Railway.

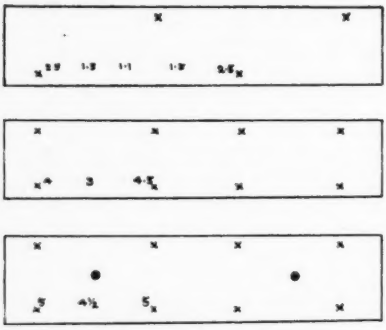
At this stage it may be of interest to group together the results mentioned above thus.

(It should be noted that these data are not full enough to be taken as illustrating the general practice throughout the whole of the railways. They are merely based on tests in a certain number of coaches visited; but as far as possible carriages lighted by typical modern methods were studied.)

Mr. Dow added that he had tried, in his conversations with railway engineers, to form some idea of the light furnished by the old oil lamps now rarely met with. Several of those he questioned were of opinion that such lamps frequently gave under one candle-power; a carriage lighted by a single central oil lamp would, by modern standards, give a very poor illumination indeed.

In a subsequent stage two flat-flame burners, each rated at about 8 c.p., were used in a central clear glass basin. The illumination even in these circumstances would probably be only about half that provided to-day.

Mr. Dow then passed on to some data obtained on the tube railways.



1890.

Four 16-c.p. carbon lamps, two on each side.
1·1—2·5 ft.-candles.

1893.

Eight 16-c.p. carbon lamps, four on each side.
3—4·5 ft.-candles.

1895 onwards.

Eight 16-c.p. carbon lamps, four on each side, and two central bowls, each containing two 16-c.p. carbon lamps.
4·5—5 ft.-candles.

Afterwards metal filament lamps were substituted.

FIG. 6.—Tests made in a typical carriage on City and South London Railway. The lights in the carriage were rearranged to reproduce the conditions in 1890, 1893, and 1895 onwards. (March, 1914.)

Illumination measured in a horizontal plane on level of passengers' knees.

Broadly speaking, the conclusion one would draw from these tests is that an illumination exceeding 1 foot-candle on the passengers' knees is provided by most of the typically lighted carriages of the railways of to-day. There would, therefore, be no hardship in suggesting this as a tentative standard, and, as the book or paper would in general be held somewhat higher than this level, it is probable that the actual reading illumination in reasonably well-lighted carriages would approach 2 foot-candles. It is for railway engineers to say how far it would be practicable to increase this figure; judging from the public appetite for improved illumination, generosity in this respect would be well repaid.

Through the courtesy of Mr. Macmahon an opportunity had been afforded of making a definite comparison between the conditions in the carriages on the City and South London Railway, when the tube first started in 1891, and at the present time. The changes that occurred are summarised in an adjacent illustration. It is interesting to notice that although the original illumination was not high judging by the modern standard of tube lighting, it was doubtless considerably above that prevailing in most railway carriages of that time. The newspapers of the period referred to these carriages as being most brilliantly lighted.

However, it should be mentioned that these experiments were made in a stationary carriage, drawn into a siding, the lamps being adjusted to reproduce as far as possible the old conditions. But in the early days of the tube the voltage on a moving train often dropped heavily, with the result that the lamps were giving but a fraction of their rated candle-power. Mr. Dow added that Mr. A. P. Trotter, in his paper before the Institution of Civil Engineers in 1892, had given the measurement of illumination in the District Railway carriages as being 0·3—0·9 foot-candles.

FLUCTUATION OF ILLUMINATION IN TRAINS AND TRAMS.

(Data published by Prof. J. T. Morris in the *Architect and Contract Reporter*, 1910.)

Route.	Type of Lamp.	Illumination in foot-candles.		
		Max.	Min.	Aver.
Piccadilly Railway	Carbon	1·7	0·55	1·0
Great Northern and City Railway ..	Tantalum	0·95	0·65	0·8
Central London Railway, East half	Tantalum	1·7	0·85	1·0
Central London Rly., West half ..	Carbon	1·8	1 3	1·6
Metropolitan-District Railway	Carbon	2·0	1·05	1·6
Metropolitan Railway	Carbon	2·6	0·6	1·6
Aldgate to Stratford Tramway ..	Carbon	1·75	0·28	1·0

It would appear that the tendency towards increased illumination on the tubes is still going on. In 1910 Prof. J. T. Morris published the results of a series of tests, which, fortunately, were made under conditions not dissimilar from those now described. Mr. Dow remarked that the data he had obtained in the tube were by no means exhaustive, being mainly obtained on casual journeys during the last few weeks; but they certainly suggested that the illumination now prevailing is distinctly higher than that recorded by Prof. Morris four years ago, being usually between 2—4 foot-candles, whereas the average values recorded by Prof. Morris were all under 2 foot-candles. It is also worthy of note that in the carriages on the Underground Railway, lighted on the very latest plan, as much as 7 ft.-candles is provided.

Taking a broad view of the arrangement of lights in carriages visited, Mr. Dow remarked that the advantages of good methods of shading hardly seemed to have been sufficiently recognised as yet. In general clear glass globes were used, and it must be remembered that the metal filaments and the small mantles brought to incandescence with oil-gas were both operated at a decidedly high intrinsic brilliancy. On the tubes particularly the long lines of unscreened filaments were distinctly trying. He was glad to see that more recently it had become usual to frost the lower parts of the lamps; and the diffusing globes introduced by Mr. Roger T. Smith in the Great Western Railway carriages seemed very suitable.

But more could probably be done by the judicious use of globes and reflectors than at present.

Through the courtesy of Mr. Agnew, Mechanical Engineer to the Underground Railways, an opportunity was provided of taking some photographs and measurements in some of the most recently equipped District Railway coaches at Ealing Common. These coaches are approximately 50 ft. long and 7½ ft. wide. On the coaches with clerestory roof there are twenty 25-candle-power carbon lamps with frosted tips used in these coaches, and measurements showed that the illumination at the level of the passenger's knees was up to 5 foot-candles almost everywhere, and nowhere less than 4 foot-candles. No doubt the reading illumination could be increased considerably by using reflectors; but it must be remembered that these lamps have an important function to perform in lighting up advertisements. On the other hand, many people must find it a drawback to see the bare filament when they look in this direction. It occurred to him that it might be possible to screen the lamps on the sides facing the passengers by a small translucent device which could also be used for advertising devices.

It will be noted that in these carriages carbon filament lamps are mainly used. This is one of the cases referred to by Mr. Kilburn Scott in which ample electrical power is available, and the question whether metallic filament lamps should be employed is still an open one.

We now come to a new method of lighting that has been fitted up so far on half a dozen new coaches with arch type of roof. Mr. Kilburn Scott described some of the methods used on the American tramways, and it is interesting to notice that experiments on similar lines are being conducted in this country. As the photograph shows, the main illumination in these carriages is provided by a series of six central diffusing glass bowls, each of which carries three 25-candle-power lamps. In addition, there are five bracket lights on each side of the carriage and one at each end of the carriage, making 30 in all. The illumination has been increased proportionally, being as much as 7 foot-candles over the greater part of these coaches. No doubt the scheme would be subject to slight alteration. The mild luminosity of the central lights seems a good feature, but it might be suggested that the bracket lights should preferably be shaded as they are at a rather low level—which, Mr. Dow added, he understood it was intended to do.

The return to lights down the centre of the carriages is interesting. This seemed to be mainly the result of the fact that the shape of the coaches has been altered, a uniform roof with a top ventilator being now used. With this plan there is nothing to prevent the light from the central units illuminating the advertisements satisfactorily. A feature of these new carriages is the extensive use of steel, practically all the carriage fittings being now made of this material. The lamp fittings are composed of aluminium.

In conclusion, Mr. Dow expressed his indebtedness to the courtesy of the engineers of the companies referred to, who had gone to considerable personal trouble in enabling him to collect this

Old System.

Bare lights down side of carriage.

New System.

Central lights in diffusing glass bowls and brackets.

FIG. 7.—Underground Railways.

information. He also wished to acknowledge the valuable aid of Mr. Mackinney, who had taken the photographs shown.

Professor J. T. MORRIS said there were three objects to be attained in the lighting of a railway carriage. First, that passengers should be able to read; second, that the carriage should present a pleasing and bright appearance to passengers on entering, and third, that advertisements should be able to be seen. The last, however, was largely a financial question. He thought that if suitable shades were used, frosting of the lower half of the lamp was not perhaps absolutely necessary although still desirable. With regard to the colour of the woodwork, Mr. Scott had mentioned a case in America where, although the watts consumed had been reduced by something like 20 per cent., the illumination had gone up. This was attributed largely to reflectors, but the speaker believed that

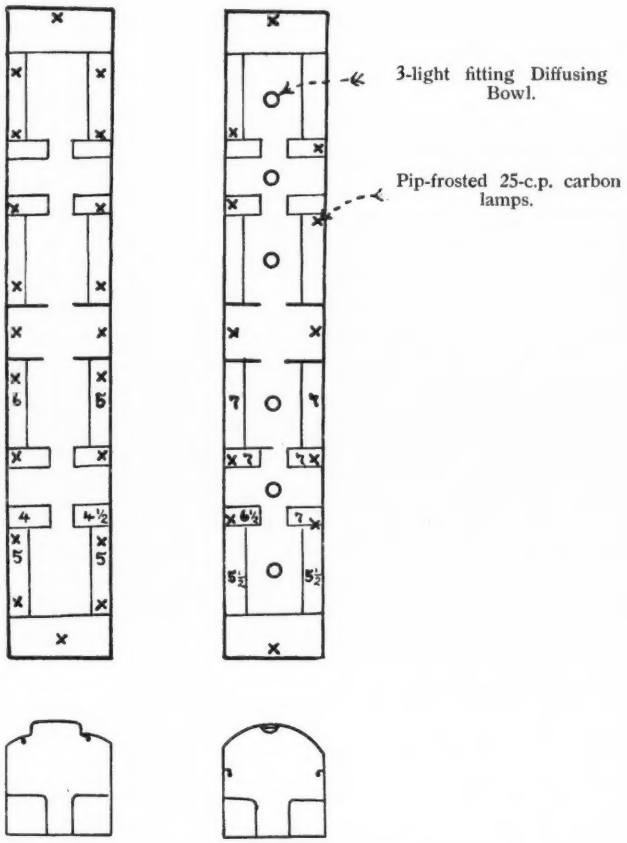


FIG. 8.—Underground Railways, London.

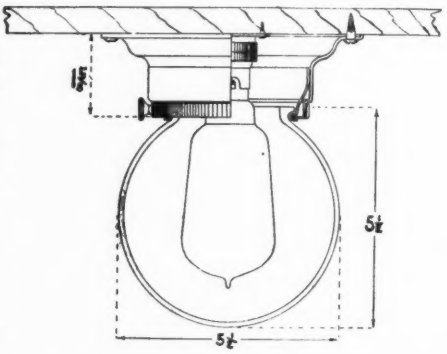
had that carriage had a white roof an almost equal increase would have been obtained without the expense of the reflectors.

The experiments which he himself had carried out four years ago, and which had been referred to by Mr. Dow and Mr. Scott, he would not guarantee to be accurate within 5 per cent. as to their absolute value. That work was carried out with the object of studying the *fluctuations* in illumination, and the ratio of the highest to the lowest values obtained held perfectly well. Train journeys were taken on the Inner Circle, Piccadilly Railway, Central London Railway, Great Northern and City Railway, and then on the Aldgate electric tram, and the range of fluctuation found was as follows:—On the Piccadilly Railway the maximum was 1·7 and the minimum 0·55, a range of 3 to 1: on the Great Northern and City Railway the variation was very much smaller, 0·95 to 0·65, about 1½ to 1. In this case Tantalum lamps were used, and in the first case carbon lamps. On the District Railway the fluctuation was 2 to 1, and on the Metropolitan 4 to 1, but on the tramways the case was much worse.

The illumination of tramcars varied much more than on electric railways, and on the Aldgate to Stratford line there was a range of 7 to 1. Mr. Scott had referred to the total extinction of the lights at intervals on the tramways when crossing points as objectionable. A somewhat similar drawback was to be observed on the Great Northern and City Railway at Drayton Park, and also at Golder's Green, when running out into the daylight, and these sudden changes were undoubtedly exceedingly trying to the eye. The speaker believed that 3 foot-candles for trains would be a reasonable figure, but he would fight shy of anything approaching 7, as being "too much of a good thing."

Mr. R. A. IVES said that apart from the actual question of illumination there were certain mechanical difficulties which have to be overcome: the first was with regard to vibration and breakage of lamp filaments; the second, the prevention of fracture and working loose of reflectors; and the third, the prevention of lamps working loose in holders.

Referring to the vibration on the electric lamp, he showed a slide of an anti-vibrating device which he suggested that it might be possible to apply to train-lighting units.



He also said that it is found in practice that the ordinary means of securing reflectors is unsatisfactory, owing to the vibration of the train; he showed a diagram illustrating a method for obviating fracture or working loose of the reflector. The fitting being so designed that three spring clips are forced into engagement by a cam ring, the latter is in turn fixed by a clamping screw so that it is impossible for the reflector to jar loose. These fittings had been applied to the National Steam Car Company's buses, and since these had been installed the number of broken reflectors had been considerably reduced.

Finally he mentioned the necessity for using suitable lamp-gripping devices, and showed a slide giving a sectional view of an Edison screw lamp-holder with a specially designed spring which forms an effectual lamp-grip.

Mr. V. H. MACKINNEY said that for railway carriages the central suspension method of indirect or semi-indirect lighting was not usually feasible owing to the absence of sufficient height in the coach. These methods were inefficient as compared with direct lighting even when the most favourable conditions

prevailed, and it must be remembered that for the majority of the railway rolling stock of this country energy consumption was of first importance. It was true that the "well" type of ceiling, now commonly found in corridor coaches and in some compartment ones, gave increased ceiling height, but a careful study of them showed that but a small percentage of the light thrown on to such ceilings found its way to the working plane; and, therefore, even in these cases the indirect or semi-indirect methods were found to be uneconomical and direct lighting was preferable.

The single point in the centre of each compartment was not good, but the 3 and 5 point direct methods of the G.W.R., employing suitable diffusing globes, were as near the ideal as one could expect, bearing in mind the many conditions to be fulfilled.

Mr. Mackinney thought that the direct bracket method had the serious disadvantage of being "glaring" as ordinarily installed. The brackets had of necessity to be low, and in the case of the compartment coach were so near and directly in the line of sight that they required careful shading. He had noticed a novel and ingenious form of globe in a compartment on one of the local steam railways. It was an ellipsoid in shape with a clear and comparatively wide zone letting the direct light from the lamp pass to the seats immediately below, but the portion of the globe which faced towards the travellers on the opposite seats was "dulled" to such an extent that even the most fastidious would agree that all objectionable glare had been removed. This was an important point, because the bracket method of lighting had inherent advantages. The light from bracket points was near to the newspaper or book and fell normally upon them, and a high value of illumination was obtained without "glare" or harmful shadows.

Mr. Mackinney thought Mr. Scott was somewhat too sweeping in assuming that a higher value of illumination was afforded for first-class passengers. On most of the lines with which he was acquainted the arrangements in both the first and third classes were substantially the same, and it would be noted that some of the highest values recorded by Mr. Dow are in third-class compartments.

In conclusion Mr. Mackinney expressed disagreement with the suggestion of Prof. Morris that a good white ceiling rendered shades unnecessary. In the confined space of a compartment a good white ceiling was certainly a help, but he thought that even better results would often be obtained if a carefully selected type of reflector were used.

Mr. G. CAMPBELL said that the high values of illumination in railway carriages, referred to by Mr. Dow, must be very exceptional and local, because on long train journeys such illumination as 7 foot-candles was not generally given. He knew cases in which it was below 0·5 foot-candles. Railway companies should also pay more attention to glare. On one of the biggest northern railways the glare from the dining saloon lights was terrible, an exposed lamp being within one foot of the eyes.

Mr. ELLERD STYLES remarked that the public of to-day seemed to be asking for more and more light. He thought there was a danger of excess and that some standard of the illumination really needful was most desirable. On the other hand, while indirect lighting had certain advantages for trains and vehicles, care should be taken to avoid the gloomy effect sometimes produced when buildings were lighted by this method.

New and improved devices for the lighting of public vehicles were being brought out almost every week. Yet little improvement had been made in the illumination of taxicabs, the interior of which were often almost without light. Fortunately attention was being devoted to the matter, especially as regards the manufacture of glowlamps with small filaments, and there was a prospect of improvement.

A point still to be decided was the correct illumination for various classes of vehicles. What was really needed was a suitable reading illumination, and he thought that in some cases the switching arrangements should be such that passengers could vary the light as they desired.

Mr. R. CLAUDE BUSSELL said the proposition had been dealt with upon the supposition that every passenger who entered a public vehicle must inevitably want to read; but surely there was a large proportion of the travelling public who regarded a journey as a welcome opportunity for rest. Being one of this section, he quoted his many years' experience wherein after a hard day's work he was obliged regularly to undergo a non-stop train journey of 1¾ hours, during which he was the victim of brilliant carriage lighting, which made rest impossible. There was never any means of subduing this light, and it seemed to him the only escape for the unfortunate passenger was to lie face downwards on the seat. The Society would do well to record the fact that this other aspect of the lighting problem must be taken into account.

The CHAIRMAN, in closing the discussion, remarked that some very interesting data on railway carriage lighting had been presented, but there were problems connected with the lighting of omnibuses and tramways on which comparatively little had been said.

In omnibuses the usual arrangement in the past had been to have a lamp at each end of the vehicle which served as headlights and also threw some of their rays inside. The illumination in these circumstances was by no means even, and people most remote from the light would have considerable difficulty in reading, particularly in the days of the oil lamps. Nowadays many of the omnibuses use six lights, three on either side, spaced on the ceiling, which gave a greatly improved illumination. In most of the acetylene buses there are now seven lights—four inside and one outside to illuminate the destination board, one at rear for the same purpose, and one at the tail. He understood that the police regulations made it somewhat difficult to introduce lights inside when acetylene was used, but he recently saw a motor bus with a light in the centre which served the double purpose of lighting the destination number of the bus and improving the illumination inside.

In the electrically lighted omnibuses he had been particularly struck by a method used in one case. Lamps above the roof with diffusing glass plates underneath were employed, and this gave a soft illumination. In other cases prismatic globes and reflectors are used. Mr. Clarkson had kindly granted permission for Mr. Dow to make some measurements in some of the buses of the National Steam Car Company, which are lighted in this way. In some of the most recently equipped vehicles having metallic filament lamps and prismatic glass reflectors an illumination of 3—4 foot-candles was recorded; in others the value was between 2 and 3 foot-candles—values considerably higher than would have been recorded a few years ago.

In both motor buses and trams the vibration and the occasional flickering of the lights is a drawback to reading. He was also inclined to think that in many trams the lights are spaced at too great intervals. He had noticed that a passenger seated under a light and reading his paper only moves further along to make room for others with some reluctance; and the fact of a passenger tilting his paper sideways to catch the light is apt to obstruct the illumination from others.

In the case of tramcars he thought that there was a tendency to have too few lights, with the result that passengers in some positions found it difficult to read. He thought that it would be found well worth while to improve the conditions of illumination in such cases, as this would surely prove a strong inducement to prospective passengers.

Speaking generally, he thought those present would agree with the suggestion that the same standard of illumination should be aimed at in public vehicles as was recommended for school and library lighting. People almost invariably read when travelling now, and such incidental drawbacks as the flickering of the lights only make it more necessary to have a good illumination. The researches of the Committees on School and Library Lighting were thus proving of distinct value to those concerned with public vehicles, since they furnished a recommendation of the standard of illumination required for reading purposes by the general public.

Professor Dr. R. ULBRICHT (*communicated*) :—I have pleasure in giving some particulars of the lighting of the State railways in Saxony. As a rule incandescent gas lighting (Pintsch system) is used, the gas being generated in special retorts distributed over the railway system. Each carriage contains one inverted mantle with a protecting basket, bye-pass, and an appropriate means of screening the lights. Two varieties of burners rated respectively at 35 and 50 H.K. are used, the higher candle-power being employed in first and second class carriages and the lower in third class. The dimensions of the gasholder attached to each carriage are such as to supply gas for 30 hours continuously.

In the electrically lighted carriages self-generating systems are used, a dynamo being fitted to every carriage, but there is also a battery, having a capacity sufficient to light the carriages for six hours. The lamps in the carriages are run in parallel on a pressure of 32 volts 16—25 H.K., metallic filament lamps being exclusively employed. Each compartment contains either one or three lamps according to the class and nature of service. In some compartments there are also additional 8 candle-power tubular lamps for reading ; these are fitted under the racks (so as to throw the light over the passenger's shoulders).

MR. E. KILBURN SCOTT : I am glad that my remarks, introducing this discussion, have been instrumental in leading to the useful data prepared by Mr. Dow, which should be of considerable value to the Society.

Most of the speakers shared the view that the illumination in public vehicles should be ample for reading purposes, and it would appear from Mr. Dow's data that companies now regard this as quite feasible. On the other hand I agree with Prof. Morris that the illumination has other purposes to serve, such as the lighting of advertisements. When these consist of light-coloured surfaces they also serve a useful purpose in diffusing the light and relieving the contrast between the brightness of lamps and dark surroundings. For the same reason a light ceiling is a necessity ; and because it helps to distribute the light in the carriage. Opinion seems to be unanimous that it is not a satisfactory plan to light a compartment from a single central source (although possibly the method might be used for semi-indirect lighting). In any case I am disposed to think that some form of shade is essential, especially, as Mr. Mackinney remarked, in the case of bracket lights.

Mr. Bussell complained of excess of illumination. There may be some fortunate people who rarely read in vehicles. But in these days many people, especially those whose journey to work occupies a considerable time, find it necessary to get through some of their work in the train, and they naturally appreciate a good illumination ; others regard this as their only opportunity for light reading, and in fact the great majority of people *do* read when travelling. Mr. Bussell's complaint of too much light is probably founded on experience of unscreened mantles and filaments, and I do not think he would object to a good reading illumination if the lights were properly shaded.

Mr. Mackinney referred to the value of reflectors for concentrating the light downwards, while Professor Morris contended that the reflecting power of a good white ceiling would do what was necessary in this respect. The results quoted from Hibben's paper suggest that proper shading does accomplish an economy, and, if carefully selected, diffusing glassware should give a more decorative effect than bare sources will do. There seems room for new methods in this respect.

As Mr. Ives pointed out, there are certain mechanical difficulties to be met in the use of globes and means of attaching them.

Turning to tramways and tubes, there is no doubt that one of the chief imperfections in the lighting is the fluctuation in the illumination, although it was somewhat surprising to learn from Prof. Morris that the light actually varies in the ratio of seven to one. On some tramcars the interruptions seemed to be due mainly to the fact that only one plough was used. Possibly if *two* were employed the lamps would not go out.

Mr. Mackinney doubted my suggestion that the illumination in first class carriages

exceeded that in the third class coaches. I believe that it is now more usual to provide identical illumination in all classes than it was a few years ago; nevertheless, Mr. Dow's contribution, and also the communication received from Prof. Ulbricht relating to State railways in Saxony, show that there are such variations.

In conclusion I may say that I had no wish to criticise unduly directors or engineers of railway companies, especially in view of the fact that there has been, in recent years, a very considerable improvement in railway carriage lighting. Engineers generally are interested in the matter, and anxious to make improvements, but it is the duty of such Societies as this to exert their influence with the public, and through them on the directors, so as to ensure that the progress shall be as rapid as possible.

THIRD INTERNATIONAL CONGRESS ON DISEASES OF OCCUPATION.

To be held in Vienna, September 21st—26th, 1914.

THIS forthcoming Congress is receiving considerable attention in this country and has received influential patronage. The Home Secretary is the Hon. President, and the President of the Organising Committee is Sir Thos. Oliver. Dr. T. M. Legge is to represent the Home Office and is also Chairman of the Executive Committee.

The proceedings should be of interest to many members of the Illuminating Engineering Society, and there will doubtless be a number of items bearing on illumination.

Those interested should apply to the Hon. Secretary, Dr. Dearden, 168, Trafford Road, Salford, Manchester.

FIFTH INTERNATIONAL PRINTING, STATIONERY AND ALLIED TRADES EXHIBITION.

THIS Exhibition is to take place at the Agricultural Hall from May 13th—30th. The support of the industry and trades interested promises to be exceptional, and altogether the Exhibition should be an interesting one. Application for tickets should be made to the Organising Manager, Mr. F. W. Bridges, 124, Holborn, London, E.C.

A COMING ACETYLENE EXHIBITION.

WE understand that an acetylene exhibition is to be held in Paris during the autumn. The date has not yet been fixed, but it would appear that the exhibition is to be on a considerable scale, and it will doubtless be of interest to many of those connected with the industry in this country. We observe that the President of the Committee of Organisation is M. L. de Seynes, President of the Union Française des Acétyléstes. The General Secretary is M. Pierre Rosemberg of the Office Central de l'Acétylène, 104 Boulevard de Clichy, Paris.

SOUTH METROPOLITAN ELECTRIC LIGHT AND POWER CO.

EXHIBITION IN LEWISHAM.

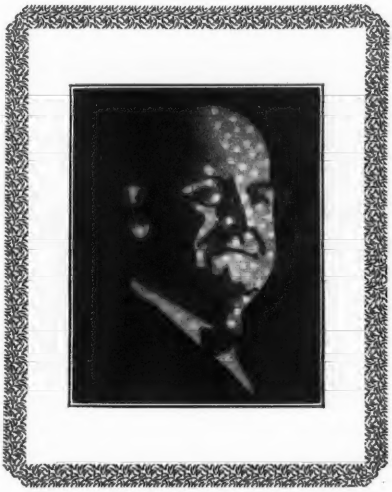
TOWARDS the end of last month the company arranged an exhibition, "Electricity in the Home," in their showrooms in the High Street, Lewisham. We understand that the Exhibition provided an object lesson in the progress of electric illumination since 1879. It is pointed out that a consumer can get nine times the illumination that could be obtained for a given consumption of energy in 1879. But it is important that he should understand how to get the best value by using this light wisely, and therefore educational exhibitions should be welcomed.

SHORT NOTES ON ILLUMINATING ENGINEERING.

AN ELECTRICALLY LIGHTED SHADOW PORTRAIT.

THE illustration shows an ingenious shadow portrait of the Hon. W. J. Bryan, which was described in a recent number of the *Electrical World*. The features of the face are formed by grooved channels, at the base of which lamps with opal colour caps on the tips are inserted. It will be observed that the recesses are strongly illuminated and bring out the main features of the face, but the rays of light do not strike the outer portions of the surface which are left in comparative shadow.

In addition, the lamps were obscured in such a way as to appear practically of the same intensity as the reflecting surface at the bottom of the channels. They were therefore indistinguishable from their surroundings when viewed from a distance. The colours of the lamps can be selected to resemble the tints of real life. The portrait was exhibited at a recent National Conservation Exposition at Knoxville, Tenn., where Mr. Bryan was a guest of honour, and is stated to have been decidedly life-like.



Electrical Shadow Portrait of Mr. Bryan.

A NEW GAS-LIGHTED SUBWAY.

THE new subway from the Mansion House Station has recently been opened, and is lighted throughout by miniature gas lights. The subway is decidedly brightly lighted, but the effect would perhaps be better if the direct rays of the light were shaded from the eyes. In a narrow passage this plan is almost always desirable, and has been followed on most of the subways on the Underground railways.

MINIMUM ILLUMINATION PERMISSIBLE FOR SAFETY.

In a recent article in the *Electrical World*, Mr. Ward Harrison remarks :—" Considered only from the standpoint of safety 0·25 ft.-candle may in most instances be taken as the lower limit of permissible intensity in an industrial plant." It will be recalled that in the section of the last report of H.M. Chief Inspector of Factories (1912) dealing with foundry-lighting, Mr. D. R. Wilson pointed to the desirability of a figure near the above being maintained. Again, in the discussion of the lighting of railway platforms in January, 1912, a minimum figure of 0·25 ft.-candle for main platforms was considered very usual.

There seems, therefore, to be good precedent for suggesting this figure. In addition it would probably be found to be justifiable on physiological grounds, for if the illumination falls much below this value a profound change takes place in the retina of the eye, and we approach the condition known as " night-vision "—when the eye is in a state of instability, and finds it very difficult to distinguish surrounding objects.

PORTABLE DISPLAY PANELS FOR WALL FIXTURES.

A recent number of the *Electrical World* describes an appliance for exhibiting electric wall fixtures. This takes the form of a movable easel which can be set up at any place in the showroom to suit the customer's convenience. The fitting is mounted on the easel surface, which is made of yellow pine stained and grained to resemble oak. It is supplied with current by means of a flexible plug-connector at the back. By using a series of such panels quite a variety of fittings can be shown to a prospective purchaser in quite a short time.

LARGE LANTERNS.

How should they be Lighted ?

This illustration shows a series of large glass lanterns typical of those hung outside many public-houses in London to-day. In view of the expensive character of many of these ornamental cut-glass fixtures one can only imagine that in the days of flat-flame burners many people must have been more liberal in their views of expenditure on lighting than they are to-day.

The conversion of these fittings to modern illuminants is an interesting problem. A small light in this vast glass area hardly shows them to advantage. Would not the effect be better if white translucent glass could be substituted, this causing the lantern to appear luminous as a whole ?

CHANDELIERS.

By an Engineering Correspondent.

The human side of history is often reflected to a remarkable degree in the fluctuating fashions of architecture, furniture, and interior decoration. Given a taste for the antique, together with a *flair* for historical-detective work, and your moralist is frequently tempted to take a speculative excursion into the realms of a bygone era, and to deduce the trend of a period from its chairs, screens, fireplaces, or even wall-paper.

"Tell me what a man laughs at," said Carlyle, "and I will tell you his character." With less daring we might say, show us the bedsteads and candlesticks of a particular epoch and we will undertake to make an inventory of its social and domestic manners. For this method of research the accessories of illumination, which have come and gone throughout the ages, provide many valuable clues. From the crude torchère of the ancients down to the elaborately fitted electrolier of to-day, there has always been something in the mere outward form of the light-holder to link us up with the human story. The study of chandeliers alone is interesting, if for no other reason than that it affords a striking instance of man's delight in making a luxury of his necessaries—of putting the crown of art on the discoveries of science.

As with many another ornament that has come eventually to grace our homes and halls, we find that the chandelier—or hanging candelabrum—was first used for the lighting of churches. It superseded the old oil "lampas," which was set in a metal "basine" and suspended by a chain or rope from the roof. The framework of the first chandeliers was probably made of wrought iron, and Pope Hadrian (772—795) is recorded as having presented a particularly massive example to St. Peter's, capable of holding 1,370 candles. Gradually this bold system of lighting extended to mediæval castles and council chambers, and the cunning workmanship of the jeweller and goldsetter was often employed to enrich the stems and branches of the candelabra with precious gems and golden embossments. In Italy and France, especially, there was also a fondness for painting these pendants in the most brilliant colours. The wooden chandelier—the fashion of which spread all over Europe between the tenth and fourteenth centuries—gave the wood-carver a conspicuous object on which to exercise his genius.

The ecclesiastical specimens—such as are still to be found in some of the cathedrals of Spain—were often of rare beauty; the religious imagination of the artist was given free play, and both hand and heart united in the creation of gorgeous ornaments designed alike for the service of man and the adoration of God. Two fifteenth century Gothic chandeliers are to be seen in the Temple Church at Bristol. On the top of one is carved a figure of the Virgin, the other being surmounted by a small statuette of St. George. The palaces of Genoa and several of the châteaux in Southern France can also boast the possession of early work in this *genre*. Exquisitely carved wooden chandeliers still beautify the salons of some of the aristocratic mansions of England—those in Speke Hall and Lansdowne House being worthy of special mention. It should be remarked, however, that it was not till the reign of William III. that the wooden chandelier became really fashionable in English houses, and even this had but few branches, and generally had to be supplemented by side candles on the wall.

Chandeliers of wood, iron or brass (made, as a rule, with balls on the stems) seem to have been in common domestic use in Holland in the early seventeenth century. But there is evidence that even long before that period this useful decoration was not unknown among the Dutch; for in the "Flemish Interior," painted by Jan Van Eyck in 1434, a chandelier with branches for candles is shown hanging in the centre of the apartment. Glass chandeliers were manufactured extensively at Murano in the sixteenth century, and adorned with the floral devices for which the Venetians were famous. By the time of Charles I. chandelier lighting had become a familiar

luxury in the homes of the nobility and middle gentry of this country; and at the Restoration the dining rooms and ballrooms of the great were irradiated by as many as three and four tiers of lights burning in magnificent brass chandeliers. Wood, as we have seen, came in with William; and, owing partly to the indoor tastes of fashionable society, for the next hundred years or so, running more to gaming and dicing than to large social gatherings, very little improvement in lighting arrangements took place till about 1800. To the call of "more light," William Kent and other architects of the time responded with an elegant system of illumination that banished the Georgian gloom for ever. Changing recreations demanded a more brilliant central lighting, and the type of chandelier installed by Kent has been found easily adaptable to modern uses. The first artistic attempt to harmonise the chandelier with the rest of the furniture and fittings was made by Chippendale, who published a set of ten designs in 1760. It is doubtful, however, if any of these were executed.

The ugly glass chandelier—or, more properly, "lustre"—so common at one time on the mantelshelf of middle-class families, is now quite *demode*. It was usually a French production and came from Dinant, the ware generally being known as *dinanderie*. References to these small domestic reflectors are fairly frequent in the pages of the Victorian novelists, but the things themselves are rarities now, even at the "marine-store dealers." Dickens pokes mild fun in one of his sketches at "the remains of a lustre without any drops," and Disraeli emits a more superior sneer at "these tasteless lamps and tawdry chandeliers, evidently true cockneys," in "Coningsby." Some very fine examples of large, hanging candelabra, with English cut-glass pendants, are extant at Penshurst; and in its highest form the glass chandelier was often a true and chaste piece of art.

Chandeliers were also made of silver, the richest specimen of which, in use to-day, being the one at Knole. The most elementary consideration of the subject is sufficient to prove what a vast variety of craftsmen have devoted their talent and skill at different periods to the construction of this most lustrous adornment. The blacksmith, the goldsmith, the silversmith, the glass cutter and the cunning carver are but a few of the artificers who have helped to make a fitting habitation for the wonderful god, Light. The light has changed through the centuries, and a different power shines in the branches of the chandelier to-day from that which served the mediæval churchmen. But the inspiration of the chandelier itself survives, and is found as adaptable to electricity as to candles.

HOW GAS WAS STOLEN—AN INGENIOUS DEVICE.

A RECENT number of *The Gas Industry* describes a highly novel and ingenious method of avoiding payment for gas obtained through the slot meter. The Manager of the Honolulu Gas Company discovered that he had one consumer whose meter never contained a coin, and who nevertheless managed to get his gas with perfect regularity. Eventually the puzzled company, on the understanding that they would not prosecute, induced him to explain how the trick was done. He took them at their word and produced a steel mould of a coin and a freezing machine. He poured a little water into the mould and a few seconds' application of the spray turned the water into a hard ice disc the size of the coin. This he dropped into the meter. The ice performed the work of the coin and, after a short time, melted and ran out. The water went into the bottom of the machine and gradually evaporated, leaving no trace behind.

Whenever the time came round to insert a new coin this process was repeated.

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

A RECENT volume of the Transactions of the American Illuminating Engineering Society contains a variety of articles. E. J. EDWARDS and W. HARRISON deal with **Office Lighting.** The installations are described with photographs and full illumination data; it is interesting to see that "surface brightness" values for the chief objects in the rooms are also given. A picture illustrating six alternative types of units is shown and the authors work out the consumption of electricity necessary to give 5 ft.-candles in each case. It may be noted that the amount required with indirect lighting was approximately twice that for the direct system (lamps in prismatic glass reflectors), semi-indirect lighting taking an intermediate position.

Somewhat similar figures are given in the contribution in the same issue by ALDRICH and MALIA, who describe a large office installation with indirect lighting. They give the relative efficiencies of the direct and indirect systems as 55 per cent. and 38 per cent. respectively. These investigators also carried out experiments on the deterioration due to dust. They found that with all the systems studied (direct, semi-indirect and indirect) a diminution in illumination of 10 per cent. during the month occurred; glassware should therefore be cleaned monthly.

Other contributions in this number include an article by ROSCOE SCOTT on the **Evolution of the Lamp.** Illustrations of many early Egyptian lamps, oil lamps, pine splinters, &c., are given, and the paper is concluded by a useful series of references.

Finally we may note the contribution by C. A. PETERSON on **Combination Fixtures,** in which the author discusses the design of fixtures, in which gas and electric lamps are combined. To secure an artistic result in these circumstances requires no little skill. A number of typical fixtures of this kind are illustrated, and something is said on the selection of fixtures suited to various types of interiors.

Several articles deal with artificial daylight.

A recent article by H. E. IVES on the subject suggests the use of "**artificial daylight spectacles,**" *i.e.*, spectacles equipped with special tinted glass which causes the objects illuminated by artificial illuminants to appear the same as by daylight; naturally the variety of glass used has to be selected with reference to the illuminant, *i.e.*, the pair of spectacles designed for use with incandescent gas light might not answer with electric light and vice versa.

An article by LUCKIESH (*Elec. World,* April 4th) discusses new applications of coloured light in connection with advertisement and spectacular lighting. He suggests that by selecting the colour of the light used to illuminate a picture old and faded pigments can be made to appear fresh and vivid. The article also shows how, in some lights, objects of certain colour in a picture can be made to disappear.

Several journals refer to a novel method of lighting proposed by W. D'A. RYAN for the **Palace of Horticulture** at the coming Exhibition in San Francisco. The dome is made of glass and on this an image of a large screen illuminated by a battery of searchlights is to be imposed by means of series of lenses. Various colour-changes will be available, and there is also a special lens, broken up into small segments, which is intended to produce a "spotty" effect, which will be constantly altering and will make the dome appear "as though there were millions of tiny tadpoles squirming about in it"—a very curious effect!

L. R. INGERSOLL (*Elec. World*, March 21st) describes a new form of instrument for testing the **glare from shiny paper.** It utilises an eyepiece, half of which is covered by a smoked glass and the other by a Nicol prism. Through this the specimen of paper is viewed at an angle such that the directly reflected light from it is completely polarised. Hence the amount of turning of the Nicol necessary to cause both sections of the field to appear equally bright will be a criterion as to the percentage of "directly reflected" light, *i.e.*, of the degree of glaze.

Finally we may note in *Science et Art d'Eclairage* a contribution dealing with the lighting of motor-cars. The first section discusses the future of the accumulator in relation to car-lighting, the second deals mainly with the use of the oxy-petrol flame, playing on a small pastille of incandescing material, which is used for headlights. It is stated that by this means a light of 1,600 candles without reflector, is obtained; and that by a suitable mangin reflector a beam equivalent to 120,000 candles can be produced.

ELECTRIC AND GAS LIGHTING, &c.

The *Elektrotechnische Zeitschrift* (March 19th) contains a summary of the year's electrical progress in Germany. A section of the report is given up to lighting. The chief event has been the introduction of half-watt lamps, which are said to have now a life of 800 hours, with a diminution in c.p. of only 20 per cent. during this period. The Moore light is also discussed. The development of this illuminant in Germany has led to special regulations being framed by the Lichtkommission of the Verband deutscher Elektrotechniker with regard to testing the illuminating value. It is suggested that this should be done on the basis of the horizontal illumination produced over a certain area by a tube of specified consumption.

A. FROGET (*Science et Art d'Eclairage*, March) contributes an article comparing the efficiency of arc lamps and half-watt tungsten lamps. G. R. MYLO describes the details of arrangement of the electrical signal lamps installed for the purpose of controlling the river traffic on some of the bridges in Berlin.

H. O. SWOBODA (*Proc. Am. Inst. E.E.*, April) describes a number of electrical miner's lamps, including the winner of the recent Home Office competition.

We may note next an article by "S" on **The Future of Gas for Street Lighting** (*G.W.*, April, 4th). The author lays stress on the need for some method of distributing the light from gas mantles more effectually, similar to the prismatic globes used with some arc lamps, which improve the polar curve and enable the parts of the pavement most remote from the lamps to be fully illuminated.

He also remarks that there is an opening for high pressure gas lamps of somewhat lower power (250—600 candles), particularly with a view to the class of work likely to be undertaken by the half-watt lamps.

Reference should also be made to a recent paper by KLEBERT before the German Illuminating Engineering Society (*J.f.G.*, March 28th). He describes various methods of using oil gas and incandescent mantles for signals, beacons, &c., and points out that these can be made strong enough now to be used on buoys or in other circumstances where there is pitching and tossing. Lights for aviation, both for travelling aeroplanes and for signals, are now attracting attention. Experiments are being made with captive illuminated balloons. The chief distinction between a flashing signal for marine purposes and for aviation is that in the former case the variation takes place mainly in a horizontal plane, while for air-traffic the signal is viewed from many different directions in space and must be designed accordingly.

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Glare from Paper (*Elec. World*, March 21st).
Practical use of Colour Effects (*Elec. World*, April 4th).

Edwards, E. J., and Harrison, W. Some Engineering Features of Office Building Lighting. (*T.I.E.S.*, Vol. IX., No. 2).

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Luckiesh, M. Use of varicoloured light in advertising and stage displays (*Elec World*, April 4th).

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Notes sur l'Eclairage des Automobiles (*Science et Art de l'Eclairage*, March).

Electric Lighting.

Froget, A. Essais comparatifs entre les arcs et les lampes intensives demi-watt (*Science et Art de l'Eclairage*, March).
Mylo, G. R. Elektrische Schiffahrtsignal-Beleuchtung auf einigen Brücken Berlins (*E.T.Z.*, April 2nd).
Swoboda, H. O. Self-contained Portable Electric Mine Lamps (*Proc. Am. Inst. of Elec. Engrs.*, April, 1914).
Die deutsche Elektroindustrie im Jahre, 1913; Elektrische Beleuchtung (*E.TZ.*, March 19th).
Lampes à Incandescence, Quelques brevets recents (*Rev. Electrique*, April 3rd).

Gas, Oil, Acetylene Lighting.

Ahrens, F. Die Eisenbahnbeleuchtung, System Dalen (*Z.f.B.*, March 20th).
Brewer, R. W. A. Country House Lighting (*Acetylene Lighting and Welding Journal*, April).
Klebert. Leuchtfeuer für den See and Luftverkehr (*J.f.G.*, March 28th).
"S." The Future of Gas for Street Lighting (*G.W.*, April 4th).
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E. T. Z.—*Elektrotechnische Zeitschrift.*
J. f. G.—*Journal für Gasbeleuchtung.*
J. G. L.—*Journal of Gaslighting.*
G. W.—*Gas World.*
T. I. E. S.—*Transactions of the Illuminating Engineering Society (U.S.A.).*
Z. f. B.—Zeitschrift für Beleuchtungswesen.

Traction Type Lamps

with Drawn Wire Filaments.

Many advantages are to be obtained by the use of Special Traction Type OSRAMS for Car and Ship Lighting.

Recent tests by tramway companies have proved the life of Osrams to be twice that of carbon lamps combined with 50 per cent. saving on lighting load and 25 per cent. increase of candle-power.

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VOLTAGES FROM 65 to 135.

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REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

Electric Circuit Theory and Calculations. *By W. Perren Maycock.* (*Whittaker and Co., London and New York*, 1913. 355 *pp.*, 120 *illustrations.* 3*s.* 6*d. net.*)

THIS book contains a simple treatment of wiring problems and calculations. It is intended mainly for students, the ground covered being mainly that required for the City and Guilds examinations in this subject. Some knowledge of electricity and magnetism is, however, assumed. Liberal use is made of worked examples, always a help to the student.

A few pages are devoted to light and illumination. The author does not regard this as coming strictly within the scope of the book, but even so the space allotted seems disproportionately small. It might well be increased somewhat in another edition.

Books :—

Nouveau Guide Pratique de l'Usager d'Acétylène. By R. Granjon and P. Rosemberg. (Office Central de l'Acétylène, Paris. 1913.)

G. F. Schaar's Kalendar für das Gas- und Wasserfach. (R. Oldenbourg, Munich and Berlin. 1913. Second part.)

Practical Illumination : A pocket-book for Engineers and Contractors and all interested in efficient illumination by electricity. By Justus Eck, M.A. (S. Rentell & Co., Ltd., London. 1914.)

Beleuchtung. By Dr. H. Strache and F. Elsler. (R. v. Waldheim, Vienna. 1913.)

Reprints of Papers, etc. :—

The Lighting of Streets. By S. B. Langlands, Inspector of Lighting to the Corporation of the City of Glasgow.

Radiant Energy and the Eye. By M. Luckiesh. (Reprinted from the *Electrical World.*)

Der Rauchglaskeil als Photometrische Schwächungseinrichtung. By Dr. H. Krüss. (Reprint from *Zeitschrift für Instrumentenkunde.*)

Das Marmorlicht. By W. Voege. (Reprint from the *Elektrotechnische Zeitschrift.*)

Die Osram-Halbwattlampe. By H. Remane. (Reprint from *Dinglers Polutechnisches Journal.*)

Die photometrische Grundbegriffe, erklärt für weitere Kreise. By Dr. J. Teichmüller. (Reprint from *Licht und Lampe.*)

Das elektrische Licht im Dienste der Projektion. By N. A. Halbertsma. (Reprint from *Der Photo-Woche.*)

An Introduction to the Study of Colour Phenomena. By J. W. Lovibond ; also *On the Possibilities of a Standard Light and Colour Unit* (paper read before the Society of Dyers and Colourists, by the same author).

Die Parallelkohlenbogenlampe. By N. A. Halbertsma. (Reprint from the *Jahrbuch für Photographie und Reproduktionstechnik.*)

Examples of illustrated articles printed on mat art paper :—*The Illumination of the Home.* By F. A. Vaughn. *Library Illumination.* By F. A. Vaughn. *The Influence of Illumination Conditions upon Eye-strain.* By A. J. Sweet. *Protection of the Eyes of School Children.* By N. M. Black and F. A. Vaughn. *Reflecting Media.* By A. J. Sweet.

Untersuchungen an der Halbwattlampe. By Dr. H. Lux. (Reprint from the *Zeitschrift für Beleuchtungswesen.*)

Transactions of the Optical Society (London) : Sessions 1911–1912 *and* 1912–1913.

TRADE TOPICS AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

VISIT TO EDISWAN WORKS.

A VISIT of the Association of Engineers-in-Charge to the above works at Ponders End took place on Thursday, March 26th, over 100 members of the Association and friends being present. The party was met by Mr. Gimingham and conducted over the Lamp Department, all the chief operations of manufacture being seen. In addition, the manufacture of holders, switches, and other electrical accessories, the foundry, and the stamping, annealing, lacquering, and other processes were shown. The tour was concluded by a visit to the General Offices, where tea was served. The Chairman of the Association's Educational Committee expressed the thanks of the party, and Mr. Gimingham briefly replied for the staff.

We are informed that **Royal Ediswan lamps** are being installed on the new Cunard liner "Aquitania," and that Edison and Swan United Electric Light Co., Ltd., have secured part of the contract for the supply of electric lamps to the British Admiralty during the coming 12 months.

The recently issued list of **Welsbach-Kern** gas radiators contains quite a complete series of illustrations. Lists have also been issued of the Company's new Outdoor and Indoor Lamps ("Sovereign," "Emperor," and "Victor"), to some of which we have referred previously in these columns.

From **H. Moss** (116, Horton Grange Road, Bradford) we receive several little lists of electrical accessories. One of the cards enclosed bears the motto "Th' Light o' Yorkshire"—apparently a metal filament lamp in a Holophane Reflector.

SIEMENS WOTAN AND TANTALUM LAMPS AND ACCESSORIES.

THIS newly issued list is attractively got up and contains particulars of several novelties. Naturally the half-watt lamps receive special attention. We notice that the tendency to use photographs of lighting installations to illustrate the use of the various units is exemplified in this production, although all the reproductions are not equally good. We expect such illustrations to play an important part in the catalogues of the future.

ACETYLENE SAFETY LAMPS IN MINES.

A COMPETITION.

WE notice that a competition for acetylene lamps for fiery mines is being organised in Geneva, and that a sum of 5,000 francs is to be awarded for the lamp which best fulfils the requirements as regards safety, and technical and economical working.

Competitors should apply to the Secretariat International du Carbure de Calcium, 5 Rue des Geanges, Geneva, for full particulars.

AUTOMATIC LIGHTING OF STREET LAMPS.

A CORPORATION desires information regarding systems of automatic lighting. Manufacturers or agents are invited to send particulars of their apparatus to Box 750, *The Illuminating Engineer*, 32, Victoria Street, London, S.W.

HOLDERS AND CANOPIES FOR HALF-WATT LAMPS.

THE coming of the half-watt lamps has brought with it certain problems, such as the design of special holders which will support the somewhat heavy lamp, which at the same time allow for ventilation and have a pleasing appearance.

New B.T.H. Goliath Holder for half-watt lamps.

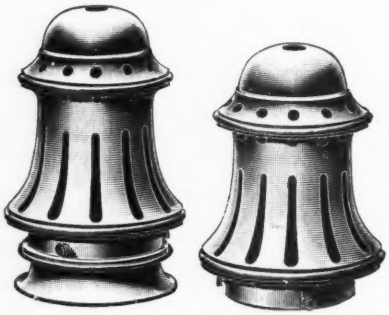
As an illustration we may take the new **B.T.H. Goliath** holder, which is made of brass and provided with special ventilating apertures which prevent any excessive heating. In addition, the general effect of the holder makes it unnecessary to adopt elaborate precautions to conceal it.

Another illustration shows the new **Benjamin** porcelain Goliath screw holder for half-watt lamps. These holders are stated to be capable of carrying 15 amperes at 100 volts. Another feature to which attention is drawn by the Benjamin Electric Ltd. is the issue of a new series of steel reflectors for half-watt lamps which are expected to be eminently suitable for factory lighting. This reflector is also illustrated.

Yet another half-watt novelty is the **Holophane** canopy, which is designed to cover up the somewhat unsightly neck of the lamp while also providing a support for suitable glassware. This is made in two forms, one for use in cases in which the canopy has not to bear the weight of the lighting unit as a whole; the other, strengthened by an internal support, is used for open type glassware where the whole weight of the fitting comes on the canopy.

Benjamin Goliath Porcelain Screw Lamp-holder for half-watt lamps.

New Benjamin Steel Reflector for use with half-watt lamps for factory lighting.



Type used when canopy supports entire weight of fitting.

Type used when weight of unit as a whole is not borne by canopy.

Canopies of this type will be found very serviceable in connection with the new Holophane glassware for half-watt lamps, such as the "Excellite" and "Reflector Hemisphere" glassware illustrated not long ago in this journal.

INDEX, May, 1914.

PAGE

Chandeliers, by an Engineering Correspondent 267

Comparison of Estimated and Observed Values of Illumination in some Lighting Installations, A
(DISCUSSION—A. P. Trotter—L. Gaster—J. Darch—J. G. Clark—T. E. Ritchie—J. Lovibond—V. H. Mackinney—E. Willis—J. Eck—J. S. Dow—R. J. Wallis Jones—F. H. Gooch—W. C. Clinton) 229

Editorial .. .. L. GASTER 225

Illuminating Engineering Society—
(Founded in London, 1909.)

Account of Meeting on April 7th 245
New Members 245
Notice of Annual Meeting 245
Discussion on "A Comparison of Estimated and Observed Values of Illumination in some Lighting Installations" 229
Discussion on The Lighting of Railway Carriages and other Public Vehicles .. 246

Illuminating Engineering, Short Notes on 265

Kennelly Graphical Construction for Mean Spherical Candle-Power, The .. 242

Publications received 272

Railway Carriages and Public Vehicles, Lighting of
(E. Kilburn Scott—L. Gaster—J. S. Dow—J. T. Morris—R. A. Ives—V. H. Mackinney—E. Styles—G. Campbell—R. C. Bussell) 246

Review of the Technical Press 269

Trade Topics 273

PERSONAL.

WE are informed that Mr. R. J. Wallis Jones has been nominated as a candidate for the Council of the Institution of Electrical Engineers.

Mr. R. J. Wallis Jones is well known to readers of this journal as a member of the Council of the Illuminating Engineering Society, and his name is also connected with many associations and committees in the electrical industry. Since the commencement of his professional career in 1881 he has had a varied experience of electrical work in different parts of the world, finally commencing practice as a consulting engineer in 1898.

We feel sure that his candidature will receive warm support from his many friends in the electrical industry.

ELECTRIC LIGHT SWITCHING.

IT will be recalled that Messrs. A. P. Lundberg & Sons have organised periodical examinations on "Electric Light Switching." We are informed that, as a result of the last examinations, 22 competitors were awarded the Advanced Grade Certificate, 41 the Intermediate Grade, and 81 the Preliminary Grade.

It is interesting to note that the first prize in the Advanced Grade went to Mr. W. D. Douglas, a member of the Illuminating Engineering Society.

WE notice that an agreement has been entered into between the electrical employers' branch of the Manchester and Salford and District Building Trades Association and the Electrical Trades Union, for a revised code of Working Rules for Electrical Wiremen.

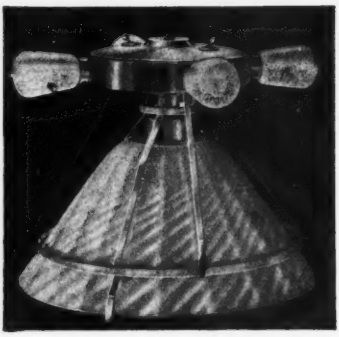
PETROL AIR GAS PATENTS.

OFFERS are invited for the purchase of the following British Patents relating to Air Gas Machines, viz., No. 16,573 of 1902, No. 18,046 of 1905, and No. 7925 of 1907, all of which are subject to a liability for Royalties to the original patentee. All inquiries should be addressed to Mr. P. J. Goodchild, 62, London Wall, London, E.C.

A FLOOR STANDARD INDIRECT LIGHTING UNIT.

THE two illustrations show a novelty in indirect lighting introduced by the **British Thomson Houston Co. Ltd.** (Mazda House, 77, Upper Thames Street, London), namely, a floor standard equipped with a lamp and reflector to direct the light upwards on the indirect principle, and also several lamps, spaced round the reflector, which emit light downwards so as to give a reading illumination below the lamp. The lamps are separately controlled so that the fitting gives either pure indirect lighting, direct lighting, or a combination of the two.

A similar arrangement can also be obtained in the form of a table standard.



Arrangement of reflector and lamps in B.T.H. "Eye-rest" Standard.

MORE SIEMENS CONTRACTS.

MESSRS. **Siemens Bros. Dynamo Works Ltd.** (Tyssen Street, Dalston) announce that they have secured contracts with the following :—

Southampton Harbour Board (Tantalum and Carbon lamps and glassware), Middlesbrough Corporation (Tantalum, Wotan and Carbon lamps), Belfast City Corporation (Carbon lamps), Newport Corporation (Carbon lamps), Salford Town Council Tramways (Wotan, Tantalum and Carbon lamps), Bolton Corporation Tramways (Tantalum lamps), Croydon County Borough (Tantalum traction and Wotan lamps).

The Manchester Tramways have also decided to renew their contract for Tantalum traction lamps.

In view of the discussion on the lighting of railway carriages and public vehicles which appears in the present number, it is of interest to notice the variety in types of lamps still being used for these purposes. In passing it may also be mentioned that the s.s. "Umgeni," which recently brought the deported Labour leaders to this country, is one of the many boats fitted with Tantalum lamps.

B.T.H. "Eye-rest" Floor Standard with utilising arrangement shown above.

SIEMENS BOHEMIAN CONCERT.

THE combined staffs of the Siemens departments at Upper Thames Street and Dalston passed a most enjoyable evening at their last Bohemian Concert at Anderton's Hotel. Mr. A. H. Bate took the chair during the first half of the proceedings and Mr. W. le Marechal during the second. Both gentlemen referred to the amicable relations and co-operation between the two departments, and this was also the subject of reference by Mr. E. C. Laughton in replying to the toast of the Dalston staff.

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The
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EDITORIAL.

The Annual Meeting of the Illuminating Engineering Society.

On pages 306—316 will be found the account of the Annual Meeting of the Illuminating Engineering Society, which took place at the house of the Royal Society of Arts on May 21st, and also the report of the Council presented on this occasion. The meeting was noteworthy as being the last occasion at which Professor Silvanus P. Thompson presided as President of the Society, and the opportunity was taken to express the great indebtedness of the Society and its appreciation of his able guidance during its initial five years of existence.

The Editor would like to add a few words expressing his personal appreciation of Professor Thompson's sympathy and support. When, about seven years ago, he was endeavouring to secure support for the Illuminating Engineering movement, Professor Thompson was among the very first to appreciate the importance of this work; and to his enthusiasm and to the very considerable help which he gave so freely at that time, the subsequent success of the Society is largely due. Although he is retiring from the Presidency, all members will be glad to know that the Society will still enjoy the benefit of his ripe experience and versatile gifts in dealing with the complex international problems before it.

In nominating Professor Thompson an Honorary Member the Society has conferred on him the greatest mark of appreciation that is at present in its power to bestow. But we would like to see in years to come a Thompson scholarship, lecture, or research fund instituted, which would permanently connect his name with the Society for which he has laboured so well.

The Society can be congratulated on having secured in Sir William Bennett, K.C.V.O., F.R.C.S., a worthy successor whose support at the present moment will be of the greatest possible value. The Society has also been privileged to add to its list of Vice-Presidents Sir Thomas Oliver, whose name is so closely associated with the study of industrial hygiene, in which subject lighting is destined to play an important part.

The medical profession justly occupies a high place in the public estimation. It is entrusted with the duty not only of curing diseases but of aiding the removal of the causes of them. It has become the guardian of the public health. Naturally, therefore, the Society looks to the medical profession to put forward the claims of good illumination and to teach the public that good lighting, whether in the home, the school, or the factory, is an essential factor in a healthy life.

The Report of the Council resembles those of previous years in emphasising the wideness of the ground covered by the Society and the large number of meetings and congresses each year at which some aspect of Illuminating Engineering is discussed. The scope of the movement is growing continually, and there are now few bodies which are not to some extent interested in illumination. It is hoped that through the medium of committees the work will be considerably extended. The existing committees of the Society have done excellent work. The reports on the Artificial Lighting of Schools and Libraries, issued last year, attracted considerable attention. We may mention that the corresponding interim report on the Daylight Illumination of Schools will be issued shortly, and we believe that this will be one of the most valuable reports on this subject yet drawn up in this country. Now it is proposed to extend the number of committees further by forming one to deal with the lighting of Picture Galleries and Art Studios, and others to deal with the Extension of Membership of the Society in the provinces, the Encouragement of Research, and similar matters.

Another entirely new feature is the suggested scheme of extension of membership in the provinces. It is hoped that by forming centres of activity in the chief cities of this country, the influence of the Society will be greatly extended, and that before long it will be possible to hold special meetings in each locality.

Meantime, the chief requirement is to increase the membership in the various districts sufficiently to make this possible, and we hope that members of the Society residing out of London will bear this in mind and take advantage of every opportunity of interesting their friends in the movement.

Public Lighting in Europe and America.

In this issue we reproduce a paper on the above subject read by Mr. C. F. Lacombe, the Chief Engineer of Light and Power in the City of New York, before the joint meeting of the American Illuminating Engineering

Society and the Municipal Art Society of New York. Readers will be interested in the comparisons Mr. Lacombe draws between the lighting of American and Continental cities. There is doubtless much in the lighting of London that might be improved, but it is at least satisfactory to find that the lighting of our main streets does not fall behind that of any modern city. In fact, in some places it excels anytning done abroad.

On the other hand, there are distinctions in the way the lights are arranged respectively in European and American cities, particularly the tendency in Europe to use powerful units at a comparatively high level, when in many American cities clusters of lamps in white diffusing globes, at lower levels, would be used.

A system of lighting sometimes used in America utilises centrally suspended arc lamps, supplemented by clusters of tungsten lamps in diffusing globes lining the pavement. The latter lights can conveniently be switched off after a certain hour at night, leaving only the centre lights on.

The soft effect produced by these clusters of globes, and their use with well designed lamp-posts, would often be appreciated in this country. We recall that some of the avenues in the Central Park in New York are admirably lighted in this way, and might furnish an example to some of those responsible for the lighting of the parks in London.

In a recent interview, referred to in the *Evening Standard*, Sir Philip Burne Jones remarked : " One thing which adds immensely to the attractiveness of a city are the bunches of trees. What would London be without its squares and parks ? Half the charm of Paris is due to its trees. Half the ugliness of New York is due to the absence of trees and gardens." Yet the Central Park in New York is well illuminated, the effect in some of the avenues being distinctly good. Why should not London, which possesses so many fine parks, make better use of them as places of recreation after daylight hours ?

We observe that Mr. Lacombe is decidedly critical of much of the interior lighting to be seen in London. For example, he was unfavourably impressed by the lighting of Westminster Abbey and other public buildings. We must own that in this respect there is great room for improvement, but critics should remember how vastly different are the conditions in a city like London, controlled by so many different authorities and departments, from those prevailing in the United States and on the Continent. In many cases matters of precedent and historic associations make people reluctant to change, and yet improvements do take place in course of time. The extreme disinclination of the House of Commons, in the past, to depart from the traditional lighting by candles is a case in point ; still gas was eventually introduced, and quite recently, as readers are aware, other changes have been made. Nevertheless, we agree that the authorities have not yet appreciated the opportunity provided by the lighting of public buildings, and a steady educational effort is necessary to influence public opinion in this direction. The time seems ripe for a special expert to be appointed by the Office of Works dealing with illumination.

One other matter that has evidently impressed Mr. Lacombe is the need for a suitable standard specification of street lighting. The paper read by Mr. Trotter on this subject last year excited a considerable amount of attention in the United States, and there is evidently a real need for some generally acceptable specification. We hope that the Joint Committee will press on with their task undeterred by existing difficulties. We are

the more anxious that this matter should be proceeded with because there is a tendency in such cases for the real question at issue to be obscured by informal discussions. These in general only cover ground that has already been traversed by the Committee and frequently bring us no nearer the desired solution.

"Beautiful London."

Our remarks on Mr. Lacombe's paper lead us to refer to a paper on "Beautiful London" read by Mr. T. Raffles Davison at a recent meeting of the Royal Institute of British Architects. Mr. Davison, who made a special reference to the work of the London Society, put the case for the planning of London on more systematic and decorative lines. He pointed out, what is freely admitted, that London is allowed to grow chaotically, that our streets consist of houses of varied size and style, and that our squares often bear little evidence of any coherent scheme of design.

His suggestions were sympathetically received by the audience, and we hope that the Royal Institute of British Architects will give fuller support to the work of the London Society, and provide an opportunity for the discussion of these important matters. We trust that in these discussions the claims of lighting, which should surely be an integral part of the design of any town, will not be forgotten. At present, it is well known there are in some of our open spaces many different and incongruous forms of lighting. When improvements are made from time to time they take the form of adding new lamps, or converting old ones. Rarely do we see a deliberate attempt to review the problem as a whole and secure a form of lighting which is in harmony with the architectural features, and adapted to the traffic requirements of the area lighted. Streets grow up without regard to the future and without sufficient attempt to forecast the increase in traffic of coming years. No doubt as time goes on this matter will be taken in hand on more scientific lines. In planning new streets, the exact purpose they are to serve, now and in the future, will be considered, and such matters as the width of roads, their connection with other streets, and the kind of lighting they require, will be schemed out together.

From the architect's standpoint the appearance of the lamp-posts by day should also be considered. The positions of the lamps should be schemed out at the time the buildings are erected, and the lanterns and posts should be things of beauty by day as well as by night. A post that is an eyesore may do much to spoil the whole appearance of a street by day; a badly placed glaring lamp, besides being a menace to traffic, is destructive of all artistic effect by night. We notice that in the city of New York the design of all new posts is submitted to an Art Commission. We should like to see a similar Commission appointed in this city, on which architects and lighting engineers would work together, to ensure that the lighting apparatus put up in our streets is beautiful as well as efficient.

The illuminating engineer of to-day is not concerned only with foot-candles. It is his function to show how efficiency can be combined with beauty; how the colour and intensity of artificial light can best be applied to produce a desired artistic effect. Few people yet appreciate how much might be done in this way towards the realisation of "Beautiful London."

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

THE HIGH INTENSITY LIGHTING OF EUROPEAN CITIES COMPARED WITH NEW YORK.

By C. F. LACOMBE,

Chief Engineer of Light and Power in the City of New York.

Paper read before a joint meeting of the Illuminating Engineering Society (U.S.A.) and the Municipal Art Society, in New York, on February 19th, 1914. [Slightly abbreviated.]

IT is with great pleasure and gratification that I appear before you to-night, for it is impossible not to feel the honour of being the lecturer of the combined societies, for the year, twice in succession, and I would therefore express my sincere thanks for the privilege of again addresssing you.

Those of you who heard my lecture on the street lighting and fixtures of New York City last year will recognise in this lecture almost a sequel to that, for it is proposed to describe the foreign methods and system of illumination where differing from ours, and also show some of their more striking fixtures.

It is also hoped that you will be interested in a description of the comparatively new movement abroad for more intense or powerful illumination on congested streets. This movement is now much in favour there and is extending rapidly. After a careful study of it, it may be safely prophesied that once tried it will be in favour here.

As this is the main difference between foreign and American practice in illumination and my time is limited, it will be necessary to make this the main topic and bring up other minor differences in connection with it.

LIGHTING OF CROWDED THOROUGHFARES.

This type of powerful lighting, in its perfection, has really had no good examples in New York or, perhaps, in this country until very recently, and generally where metallic electrode lamps are available. Examples of it exist in several places usually not sufficiently developed to impress anyone as this impression is given you in Berlin and London. A concrete instance of the lighting referred to, is that shown in Berlin. On such streets as the Potsdamer Platz, Friedrich Strasse, Koniggratz Strasse, and in London on Cheapside and Regent Street. This very powerful lighting is not at all what is known in this country as "White Way" lighting. It is not an attempt to advertise a street or to draw attention to it by some novel decorative design or spacing of the lighting units. It is very strong, permanent, municipal

lighting for the purpose of illuminating crowded streets to a point where ease of vision and consequent safety attempts an approach to the effect of daylight. In other words, one sees objects by their own reflected light, not as shadows or silhouettes against a lighter background. It was quite a surprise to me when this type of illumination was first seen on a large scale. It appeared that in spite of a consistent effort to increase greatly the intensity of the street lighting in New York, we are still behind the results obtained abroad. We are behind their results on greatly congested streets, but on such streets only. The average lighting in greater New York is as good, if not better, as some other observers assure me, than the average lighting of the two best foreign cities, viz., Berlin and London. But when the probable reasons for differences of illumination on congested streets here and there are carefully thought out, they become apparent at once, and while we must admit we are behind in results, we are not behind in the idea or effort to accomplish it.

Lighting Depends on Nature of City.

It resolves itself into the fact that our problem of the illumination of American cities, in the past, has been so different from theirs that our electrical and gas distribution system and appliances differ fundamentally. In order to obtain the advantages of the appliances used abroad, we have only to modify slightly our system and adopt lighting units of a different type in certain congested districts of a city, to produce equally good results. We must admit, however, that these appliances are not immediately available to our use in this country.

The problem of the distribution of electricity and gas in this and other American cities has been that of covering a large area of a city and its suburb with an elastic system which could be extended greatly at a minimum expense.

The demand upon our manufacturers, then, was to develop such a system, capable of giving what may be described as a thin film of illumination extended over a large area. There was no demand until the last five years for a system which would give a comparatively thick film or fairly uniform illumination over comparatively small areas of congested streets. Abroad, however, the conditions in most cities are so different from ours that a demand for heavy, nearly uniform illumination did exist in their congested and narrow streets. The cities abroad are more compact than American cities, have narrower streets and fewer suburbs, and where they have suburbs of great importance, they are taken care of independently.

This compactness probably comes from the fact that most of these cities were fortified until some time not so remote in the last century, and did not spread over large areas. A relic, pehaps, of the old protective feudal system by which proximity to the fortified centre of the overlord was one's greatest safety. From the very reason of clustering within fortifications, or close to them, a congestion in foreign cities developed earlier than congestion was apparent in our cities, and the demand for more powerful lighting naturally occurred there first. The present city of Berlin is an exception to this, as it is really a modern city, without special fortifications, such as there are surrounding Paris.

No such problem exists abroad, as in New York, where the question is the lighting of a territory of 321 sq. miles which must be provided with nearly every grade of illuminating intensity, from that suitable to a country road to that suitable to Fifth Avenue, and an extending from Far Rockaway or Tottenville to the Southern boundary of Yonkers.

They also have abroad a firmly rooted prejudice to allowing high voltage currents in cities to be installed on the street in such a way that such currents could create any risk to life, so that so far as electric street lamp circuits are concerned, except at a every few points, the highest voltage in the posts in most cities is 480 volts.

Chief Technical Distinctions between European and American Practice.

If the artist section of audience will be patient for a few moments while a technical explanation is made to the engineering section, in order to describe the actual differences between the

American and foreign system, an endeavour will be made to show the difference briefly in a technical way.

In speaking technically of the differences between our lamps and those used abroad, it should be understood that these statements are made strictly with reference to the high intensity lighting of our congested streets and are not reflections on our general systems or their usefulness. In a way, they are also made with reference to my own problem of the lighting of this city, the congested portion of which is mainly in Manhattan and a portion of Brooklyn, where we have a direct current low tension multiple system, fortunately, very adaptable to the high intensity electric units used abroad. These units, as stated, are not in use here now, but only slight modifications of our systems are required to make them available.

The demand of American conditions was met by the design and manufacture of the series system of arc lighting, either with constant current, as with the old arc lighting machines, or the later direct or alternating series or multiple enclosed lamps, or the constant current series system as obtained from alternating current by mercury arc rectifiers. All of these systems use comparatively a smaller amperage than the foreign multiple series system, and as the illumination is largely a function of the amperage, it is not relatively as high. In all our direct current multiple lamps a considerable portion of the energy is lost in resistances interposed in each lamp.

In congested areas, the wires or conductors must go underground, and it is not considered the safest practice to carry high series voltages into lamp-posts, although in this country such practice is used to some extent. Consequently, the American high voltage series system does not, in my opinion, lend itself to the conditions of a densely populated metropolitan section of a city. While efforts have been made in the last five years to meet the demand for intense illumination in congested areas, for various reasons the appliances at hand have not been universally applicable. The metallic electrode type of lamp is not at its best on a multiple low tension system. Multiple enclosed direct current flame arc lamps, with resistances and long, tenuous areas, are not yet thoroughly satisfactory, although as a laboratory product there is yet much hope of these lamps. A leading foreign authority on arc lamps, however, thinks they never will be satisfactory because when operated singly across 120 volts, so much resistance must be provided in lamp and arc to bring the imposed energy within the operating conditions of the lamps, that one loses both in steadiness of illumination and economy obtained per unit of energy supplied.

Development of Flame Arc Lighting.

To meet the foreign conditions, the manufacturers there developed lamps which are operated in multiple series of 2, 4, 6, 8, or 10 lamps across a circuit with a potential of 120-240 or 240-480 volts, with a much higher current density than our lamps. They therefore gave more illumination for the energy supplied. Flaming lamps of this type are available in this country, but are quite expensive for the reason that their life is short per trim and the carbons which must be used with them are high in cost, on account of the import duty. The cost of these carbons amounts to a tax of from $40.00 to $50.00 per year on every multiple series open flame lamp operated every night. The duty on these carbons is 65 per cent. *ad valorem*. This is not the case abroad: the carbons are very reasonable in price. (One of the foreign manufacturers of open magazine flame lamps advised me that for his 150 hour lamp the carbon cost was $\frac{1}{5}$ of a cent per hour.) The multiple series lamps used abroad are operated in groups of about 60, from an independent network served from the regular mains, with control wires brought back to the central station, obviating in this way the turning on and off of the individual lamp as on our multiple lamps in New York. This is economical, but has some inherent disadvantages.

To sum up, then, the efforts we have made here in trying to make flame arc lamps operate as single multiple lamps across the low tension direct current network of New York have not yet proved quite satisfactory, and to obtain the illumination on certain streets, as provided abroad, our arc lamps must be

designed to operate in multiple series across a constant potential system with the amperes or current densities varying for the illumination desired. Such lamps are in use abroad, using 8, 10, 12, 15, and 20 amperes at low voltages, sometimes as low as 35 volts across the arc. They are operated in multiple series, not over ten, between the distributing mains as described, and equipped with substitutional resistance to maintain the rest of the lamps in case of the extinguishment of one or more. The high illumination desired is thus obtained from these lamps with little waste in energy and with more economy per unit of illumination. In other words, we are not getting the illumination per unit of energy that they do abroad, for the reason that to date the American demand has differed considerably from the demand made by foreign cities.

With alternating current flame lamps this trouble does not exist, for the reason that it can be obviated by the use of ratio transformers raising the current density at the arc to the desired point.

To return now to less technical matters:

An interesting adaption of our flame lamps in New York to the European idea is taking place now on the suggestion of one of our members, Mr. Rhodes, to put two enclosed multiple or long burning flame lamps in series of two. In this way a longer life of carbons is obtained, less energy is lost and the arc current density increased, so gaining in illumination and economy. Such lamps in pairs of two in series enclosed on the Fifth Avenue posts are placed immediately in front of the Public Library. As you go home it is well worth observing them and making comparison with the single multiple flame lamps on 42nd Street. Each pair of these lamps in front of the library take the same energy, 1·4 kilowatts, as the pairs of standard enclosed lamps used in the other parts of the avenue. The illumination is more than double. This makes a good example of the comparison drawn, bearing in mind the additional cost of carbons, &c.

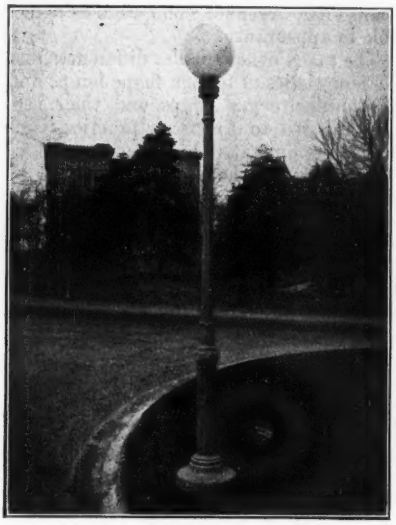
High Pressure Gas Lighting in London and Berlin.

In gas lighting a similar story may be told. Developed probably in Berlin or London about eight or ten years ago, and undoubtedly planned to compete with electricity, the high pressure gas lamp of great candle power was exploited. In 1909 London sent a delegation to Continental cities to note the illumination, and in their report to the London County Council this type of lighting was highly commended. With the improvements made in the past five years this lighting has become a decided competitor with electric lighting.

In using the term competitor, it should be qualified by this statement. The successful use of the high pressure lamp depends largely on the excellence of its maintenance. From the whiteness of the light given when well maintained, it gives an effect of brilliance to a street illuminated by this sytem that is very attractive. More so than the yellow flame arc lamp used in London and Paris and equalling that of the nearly white flame lamps of German cities. The yellow flame lamp, on account of the reflection of its yellow light from dust and moisture particles in the air, gives an effect of denseness that is almost oppressive when compared to the clear brilliance of the high pressure gas lamp.

To compare with an electric arc lamp of 12½ amperes, it requires a three-mantle gas lamp using about 60 cubic feet of gas per hour at a pressure of about two pounds per square inch. We have no high pressure gas service or mains for lighting in this city, and, of course, no high pressure gas lamps. In London and Berlin several miles of streets are equipped with this system, and "high pressure gas," as they call it in London, is used for interior lighting and particularly for the local application, quickly, of intense heat concentrated in a point for manufacturing operations. In these cities it is stated that a profitable business has been built up in this way.

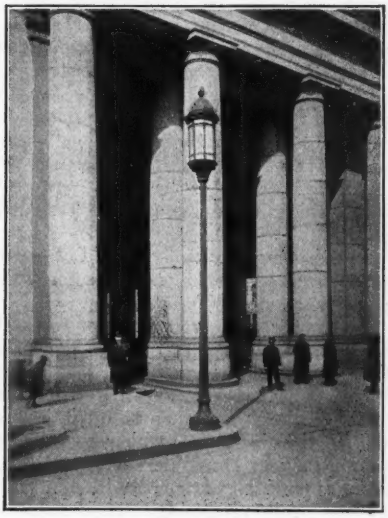
In operating high pressure gas systems for municipal lighting only, compressor stations, like electrical sub-stations, are established. These take the low pressure gas from the ordinary mains at lighting hours and compress it, using the high pressure mains as their only storage reservoir. Low pressure is on the high pressure mains during the day so that the pilot jets keep burning. When the



The Mall, Central Park.

Double Arm Standard, 5th Avenue and 57th Street.

Post carrying tungsten lamp, Central Park.



Ornamental Standard outside Pennsylvania Railway Station (8th Avenue).

Typical Lamp Posts in New York.

(*Mr. C. F. Lacombe.*)

compressors start to build up pressure on the pipes, the high pressure lamps are so designed as to light at about 700 m.m., and when the pressure falls in the morning, extinguish themselves by the reverse operation. To prevent too sudden application of the pressure to the mantle, the gas is admitted slowly by means of a thermostatic valve, which gradually opens by the action of increasing heat.

European and American Methods of Avoiding Glare.

There are two other marked differences between foreign and American practice in the placing of the lighting appliances and the methods used to avoid glare.

Abroad, the flame arc lamps and the three-mantle high pressure gas lamps are placed, with few exceptions, from three to ten feet higher than our lamps on account of their greater intensity. With this height they consider they have gone beyond the angle between the lamp and the eye of the man on the street within which the effect of glare is produced. With glare so eliminated, they use clear glass globes with flat white enamel reflectors, or reflectors which direct the major part of the illumination along angles close to the horizontal line, or prismatic reflectors, and throw along the street and downwards the full strength of the practically naked light source. In producing the high horizontal illumination of the street plane they place these powerful sources closer together than we do, and hence get the very powerful illumination desired on their crowded streets.

In this way they really get rid of most of the glare effect, although some still remains.

Here, for the very reason quoted already, on account of our less powerful light sources, we have placed our lamps lower down, thereby getting into the angle of glare; and then to obviate this we use diffusing globes which, while they produce a very agreeable effect, decrease, to an appreciable extent, the illumination we are really producing. Their method certainly produces more intense and relatively more efficient illumination than we are obtaining. On the other hand, the effect of our system is more attractive in its softer diffusion. With all respect, while a number of streets were observed that were much more intensely lighted than Fifth Avenue, none were as agreeable in appearance.

The many other smaller differences and characteristics of foreign flame lamps and high pressure gas lamps and their use, as compared to American practice, cannot be enumerated here, on account of limited time, although it is my hope to publish them in another paper later.

During my trip last summer many cities were visited: Glasgow, Edinburgh, Manchester, London, Paris, Nurnberg, Berlin, Leipsic, Dresden, Vienna, Zurich, Milan, Florence, Rome and Naples; but of all these cities only Berlin and London stand out as superior to New York and to the other European cities. Manchester, Birmingham, Glasgow, Paris, Leipsic, Budapest, Strasburg, and Munich all have certain sections of streets and some places or squares lighted on a plan similar to, but usually not quite as powerful as that of Berlin and London, but none approach these two cities in the miles of streets lighted in this way. Paris is behind either of them and is still resting on its old reputation of the "City of Light." This reputation was obtained by using small gas mantle units closely spaced, as will be shown later. Paris is just beginning to use electric flame lamps and high pressure gas lighting.

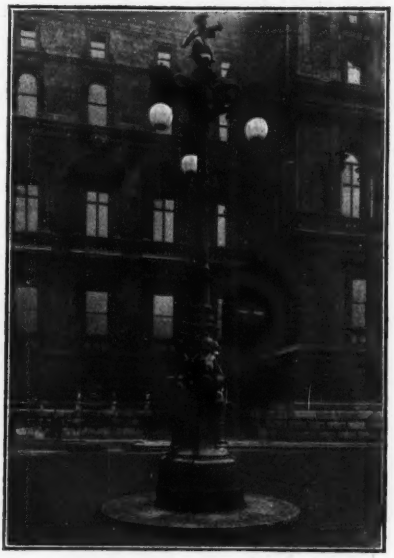
Grading of Lighting according to Importance of Streets.

In Berlin and London the lighting is graded with the importance of the streets, as to traffic, stores, &c. In Berlin, what may be designated as class A-1 streets, are the Potsdamer Strasse and Place, Friedrich Strasse, Konig Gratz Strasse, Leipsiger Strasse, Unter den Linden, Konig Strasse, Invaliden Strasse, &c. In London the same class is represented by Regent Street, Cheapside, Oxford Street, Whitehall, Haymarket, Piccadilly, Fleet and Cannon streets. In Paris, by the Rue de L'Opéra, Rue de Rivoli, Rue Auber, the Grand Boulevards, &c. Similar streets in New York would be Fifth Avenue, from 14th to 60th Streets, Broadway, from 14th to 59th Streets, Sixth Avenue, from 14th to 50th Streets, Seventh Avenue, from 23rd to 50th Streets, and 14th, 23rd, 34th,

Arc Lamp Standard (near Cockspur Street).

High Pressure Gas (Victoria Street).

Special Bronze Design
(Buckingham Palace and the Mall).



Special Standard (awarded prize in Royal Academy competition)
(Horse Guards' Parade).

Some London Lamp Posts.

42nd, 69th, and 125th Streets, between the limits represented by 4th and 8th Avenues as well as the plazas at the intersection of Broadway and Fourth, Fifth, Sixth, Seventh, and Eighth Avenues.

Class A streets abroad are also powerfully lighted. In Berlin, examples of this grade are Wilhelm Strasse, Alexander Strasse, Berliner Strasse, Bismarck Strasse, &c. In London, Farringdon Street, Lower Regent Street and Victoria Street, the Mall, the Strand, &c. In Paris, Rue de la Paix, Boulevard Malesherbes, Boulevard Raspail, &c.

In New York the streets may be represented by the Lower and Upper sections of Fifth Avenue and Broadway, Madison Avenue, Park Avenue, Third and Eighth Avenues, and many side streets within the boundaries of the class A-1 streets given above.

The third class of streets, near the centre sections of all these cities, may be termed class B and C streets, or streets not of special use at certain times of the day, and residence streets. The lighting of these streets is almost universally by mantle gas lamps with either vertical or inverted mantles from 1 to 4 and 5 in number, depending on the street or sections of same. In many cities, incandescent lamps are also used in the same way, but not, so far as observed, to such an extent as in Greater New York. In the lighting of residence streets the illumination in some sections of the foreign cities is slightly more powerful than American cities of the same class, but in the larger number of cities visited it is not equal to ours, and in several is inferior. It should be pointed out that in New York the degree of illumination given these streets is generally higher than that of foreign cities and is carried out more uniformly in gas and electric lighting throughout all five boroughs of this city, with due provision for stronger lighting in suburban towns. In this respect it appears that New York is better equipped than foreign cities, and keeps its minimum lighting above their lowest grade of illumination. Such ordinary illumination need not concern us, however. It is to the powerful illumination of class A-1 and class A streets in Berlin and London that it is desired to draw your attention, with notes as to the points of excellence in other cities as they developed. While New York perhaps started or accentuated the demand for more intense street illumination in American cities, it is not alone in its efforts to get it.

The recent installation of magnetite or metallic electrode lamps in Washington and other places, large installation of flaming arc lamps in Chicago, and a recent exhibition trial of high pressure gas lamps in Philadelphia, shows that there is a necessity for intense lighting and that it is being met in various ways.

The term used to express the unit illumination of a surface is a foot candle. This means the illumination obtained on the inside surface of a sphere of one foot radius by a standard candle of one candle-power placed at its centre. On the class A-1 streets and places in London and Berlin, the maximum illumination on approximately the street surface ranges from two to seven foot candles, much more light in the latter case than is ordinarily used in reading rooms or for general purposes of interior lighting. The minimum illumination on these streets is a quarter to one foot candles, usually above half a foot candle.

In this city the illumination is much lower. Broadway, at Times and Long Acre Squares, is probably as high illumination in any square as we have. The highest illumination found here was about 1·2 foot candles. This is largely due to the stores and electric signs, for after these are extinguished the lighting is much less. The minimum found was about 0·08 foot candles, when all lighting was on. Fifth Avenue, which is comparable in importance with Regent Street, and really is more important, has a maximum of about 1·7 foot candles, at about 8 feet from a post, and a minimum of 0·5—decidedly below that of Regent Street.

It is to be noted, however, that this intense lighting abroad is cut down at least half at about midnight. This is justifiable when such powerful illumination is used. In that case, when half this lighting is turned out, what remains is about an average of ours during the entire night.

In giving the foot candle measurements of lighting, it should be stated that they were taken by what may be termed

Views of Mexico City by day and night, showing combination of centrally suspended arc lamps and clusters of tungsten lamps in Alba diffusing globes on the pavement. This subdivision of units and use of diffusing globes is characteristic of much American street lighting.

reconnaissance measurements of my own and compared with accurate observations from detailed surveys given me abroad. The time was too short for me to make elaborate measurements to establish averages: the surveys were made to check high illumination and get illumination curves between lighting units along the street.

From this point it will probably be easier to show you the arrangements and appliances for lighting of these foreign cities by slides, pointing out on each slide the points of difference. There are a number of night photographs of the lighting. They are of no scientific value and the photographs are not even comparable as to intensity, but will give you a good idea of the effect of the intense illumination and the consequent ease and scope of vision.

To give you an idea of what the different intensities mean, then will be shown, first, two slides, one an example of seeing objects in silhouette and one giving a good idea of intense lighting, where you see almost as in the daylight. The first slide shows an automobile by silhouette against the lighting given by an arc lamp. At the intensity shown in the second slide you will see things in their colours, in correct size, and with nearly correct judgment of distance and speed of moving objects. The difference between seeing in this fashion and the strain of watching on a dimly-lighted street is all the difference between ease and discomfort, certainty and uncertainty, safety and danger. We obtain this very satisfactorily at about 1¼ to 2 foot candles, as on Cheapside. It is questionable, in my mind, if there is any necessity of going above this limit, except under very extraordinary circumstances. Indeed, the very high illumination from over 2 to 7 foot candles may be injurious for the reason that surrounding streets cannot be lighted to this extent, are consequently dim, and the sudden change from ordinary to very intense lighting, from the rapidity, strains the retina, so that a man driving an automobile rapidly might become momentarily dazzled or confused.

After the first two slides we begin with those of London streets, both day and night, showing the physical methods of hanging and spacing lamps and the effect of the illumination, as well as it can be shown by a photograph. So far as possible the slides will be shown in this manner, and the foot candle measurements given as obtained and confirmed in order to present the subject as well as we possibly can without your actually seeing it on the ground.

Mr. Lacombe then proceeded to show a series of about 80 slides.

Among those of London were views of Cannon Street, Holborn, Regent Street, Oxford Street, Trafalgar Square, &c., as well as portions of the City of London. (Some of these streets were illustrated in the paper on "The Lighting of London" published in the March number of *The Illuminating Engineer.*)

Other views related to the Place de la Concord, Paris, the Potsdamer Platz in Berlin, and to well-known streets and squares in Dresden, Milan, Rome, and other cities.

Mr. Lacombe concluded his lecture as follows:—

Conclusions.

It is hoped that with these slides and their explanations you will understand the remarks made as to the differences between American and foreign practice in illumination and illuminating appliances. You will note as far as intense lighting of congested streets is concerned, and in these only, considerable differences occur. In the lighting of all but class A-1 and A streets, we are quite as advanced as they, and as economical, when the relative prices of the commodities of gas and electricity are considered.

The use of tungsten lighting, for instance, in New York far exceeds that of any foreign city and probably antedates them, for it was adopted at an early date in this city, as it was very easily adapted to American systems of distribution, both multiple or series, alternating or direct current.

You will also note from the way they have cleared their side-walks of encumbrances that congestion is no new problem to them, but one that has been anticipated and taken care of, not only in lighting but in other ways. In this regard the efforts of the Borough President of Manhattan are far-sighted and wise in both widening and clearing the side-walks of encumbrances.

In showing you how European cities have met the problem of lighting their highly-congested streets, it is hoped to bring to your attention the fact that this same problem is confronting us here and now. To see it, you need only go on certain streets on a winter night from five to nine o'clock, or from half-past ten to half-past twelve any night, to find it. Perhaps New York, on account of its shape and its characteristic lines of travel, developed congestion first among American cities.

While New York has not yet reached London's congestion, it is rapidly approaching it. The great movements of workers from the centre of the island to their East Side homes early in the evening, the great streams of people flowing to the East River Bridges or the tube stations and ferries to New Jersey or to the great railway stations of the city *en route* to the distant suburbs, need more intense lighting that is now given. The great amusement crowds going to, or returning from, the theatres or opera late in the evening, with the great number of automobiles, taxicabs, or carriages employed to carry them, need stronger lighting than is now given. This lighting is required not only by the increasing crowds, but on account of the increased number and speed of motor vehicles over the old horse equipments. This element of high speed motors is a very important one and must be carefully considered in meeting the present condition. Taking motors into consideration, it is not so much *what one can get along with*, as *what is really necessary for safety* on streets used greatly for rapidly-moving motor traffic. For this and other reasons, more powerful lighting is needed in New York to-day almost as much as it was needed in London and quite as much as it was in Berlin. This, at least, is the opinion of those of us who have seen this illumination and its necessity. Once installed, it will never be abandoned, for the eye comfort and safety given by it, when properly and judiciously installed, are at once appreciated. Remember this type of lighting is not to attract attention to one street, nor a display for advertising purposes on a certain street, as is the practice in some cities, when part of the expense is borne by merchants directly interested in the financial returns. It should be a sustained, consistent, permanent attempt to solve the problem of lighting greatly-used streets at night during the hours they are used, so they are safe and one can see easily and instantly any approaching object. If such lighting is adopted in New York the foreign practice should be followed of turning out about half of it at about one o'clock.

At present, the mileage of this lighting needed is not more extensive than London or Berlin, and it is a good time to begin and then follow by extensions as necessary. Nor do we need to follow exactly the foreign practice. It is my belief that a little more diffusion than they have would meet the requirements quite as well, and more agreeably. The bare fact remains, however, that the appliances we need to meet this requirement are not yet available to us on account of the difference in distribution systems.

Little prevents their introduction, however, nor is it prohibitive in expense, where absolutely necessary, particularly in the electric lighting, where it is not difficult to introduce two lamps in series across 120 volts, if not four or five across 240.

In gas, it means the laying of steel mains along certain streets, which may be utilised for heating, perhaps, during the day-time.

It is probable, however, that the question of the adoption of the multiple series type of lamps and their expensive carbons may be obviated, as well as that of high pressure gas lamps, by the use of the new "Nitrogen-filled" incandescent tungsten lamp, which is at once adaptable to our series or multiple circuits, whether alternating or direct current.

When the proper fixtures and glassware are perfected to reduce the great intrinsic brilliancy of this point source light, and provide for the dissipation of the heat developed, there is no reason why it cannot be adopted in place of other appliances for many obvious reasons. It is divisible within the limits of street lighting practice, and if all we hope of it is realised, the problem may have been solved by what is really an American development, splendidly worked out.

In consequence, therefore, in New York we are really marking time awaiting results and also conducting

nearly continuously successful experiments with this lamp, both on the streets and in buildings having great halls, like our armouries. For a short time, therefore, no further question of flame lamps or pressed gas need trouble us.

INTERIOR LIGHTING IN THE UNITED STATES AND ABROAD.

Before closing, your attention should be drawn to one other difference between American and foreign installations that is most interesting to both of the societies represented here to-night. That is, the utter lack of any attempt at artistic, agreeable, or diffused lighting of interiors. A common interior lighting unit in England is the old cotton cord pendant with a bare lamp and an ill-fitting porcelain or coloured glass reflector. Except for a very few examples where pioneers of the American systems of interior lighting have succeeded in making installations, this is the rule in England, and only slight improvements are seen on the Continent. This is admitted and deplored by English and Continental illuminating engineers, who say it is only by a slow process of education that they hope to remove it.

The most glaring example observed was in Westminster Abbey. When you consider this Abbey contains most of the memorials to the progress of the whole Anglo-Saxon race and is really sacred to both America and England, one would expect the lighting to be carefully and perfectly treated. As a matter of fact, except in the chancel and choir, the fixtures in the Abbey consist of plain brass tube arms, three or four in number, radiating a foot or so from a plain brass spun ball. This, in its turn, is supported by a short rod ending in a canopy with a hook, suspended from the great height of the arches overhead to a point about 9 ft. from the floor by an ordinary cotton covered copper cord, possibly reinforced by a suspension wire. These fixtures are then equipped with bare incandescent carbon lamps with porcelain saucer-shaped shades.

If this is used in Westminster Abbey, it is not necessary to describe the practice in the rest of England. In justice to illuminating engineering in America I can say, in closing, that in interior lighting we are far in advance of any foreign practice.

The message from Mr. Lacombe on the opposite page, from the *Lighting Journal* (New York) for March, 1914, contains a summary of the chief conclusions to be drawn from his paper. Doubtless many engineers in this country will be interested in his suggestions for the improvement of street lighting in the United States. (See p. 293.)

BEAUTIFUL LONDON.

SOME of Mr. Lacombe's remarks have a very direct bearing on the lighting of this city.

There is much to be done. But we seem to see the idea gaining ground that the lighting is an important factor in rendering a city beautiful.

The strength of the movement for the improvement of London was illustrated in a paper by Mr. T. R. Davison before the Royal Institute of British Architects on May 18th. He referred to the work of the London Society. The gravest indictment, he said, that we have to bring against London is *lack of foresight*. Streets and squares are not designed on a harmonious plan but grow up chaotically. Mr. Davison quotes as examples Trafalgar Square, Charing Cross, the surroundings to St. Paul's, and other centres which have great possibilities for improvement. In any future changes regard should be had to the future when the population and stress of traffic may have enormously increased.

Not the least important of the many factors to be considered is the illumination. In order to be effective the lighting of a square should form one concerted whole; it should not consist of mutually incongruous elements

SUGGESTIONS FOR THE ADVANCEMENT OF STREET LIGHTING IN THE UNITED STATES.

There are three things needed to further advance street lighting in the larger cities of the United States:

FIRST—A LIGHT SOURCE AND APPLIANCE WHICH WILL FURNISH MORE POWERFUL AND CHEAPER ILLUMINATION, AND BE APPLICABLE NOT ONLY TO OUR PRESENT SYSTEMS OF ELECTRICAL DISTRIBUTION FOR SUBURBAN LIGHTING, BUT ALSO MEET THE CONDITIONS OF AVAILABILITY AND SAFETY IN THE CONGESTED AREAS OF METROPOLITAN CITIES.

The most promising source of relief at present appears to be the nitrogen-filled incandescent tungsten lamp. There is a strong demand by the citizen for more powerful street illumination. To my mind, this is necessary for safety on account of the increasing congestion of people and the more rapidly moving traffic caused by the use of motor vehicles. This desire is expressed in the rather crude attempts at "White Way" lighting all over the country, supported generally, either in part or in whole, by the merchants of the street. This is a blunt way of telling the municipality that the lighting on its main street is insufficient—and it usually is—for the lack of the light source and appliance first mentioned.

At present, on account of the low overall efficiency of our enclosed arc lamps, the high tariff on carbons, and our methods of placing lamps on the street, really powerful street lighting in this country is too expensive per mile.

SECOND—CLOSER CO-OPERATION AND MUTUAL EFFORT TO BETTER CONDITIONS BETWEEN THE PUBLIC SERVICE COMPANIES AND THE MUNICIPALITIES. GOOD STREET LIGHTING IS A FUNCTION OF SUCH CO-OPERATION.

My long experience in electrical work has been equally divided in years between municipal and corporation central station service. Most municipalities know little about lighting their streets and sometimes seem to care nothing about it so long as the streets have some lights on them, arranged without system or efficiency, and not carefully inspected as to the service given.

Usually their contracts are made without expert advice, and the service tendered is unwatched and neglected. Many of the public service corporations encourage this, at least by their inactivity and resistance to change. If they would show to the city their lighting ability, as well as its own lighting possibilities, remembering that their franchises to do business come from the city, and give the municipality the lowest price, close to overall costs, admirable results would be obtained. The city would only require to obtain competent illuminating engineers to advise it how to use the available funds to the best advantage in co-operating with the lighting company, and to maintain a suitable night inspection force. A well-lighted street and a well-lighted city attract people as a candle flame attracts a moth. People mean business and business means prosperity for both city and company.

THIRD—A STANDARD SPECIFICATION FOR STREET LIGHTING. AT PRESENT WE ARE OPERATING UNDER A HYBRID ATTEMPT AT A COMBINED ENERGY AND CANDLE-POWER BASIS. THIS LACK OF A STANDARD SPECIFICATION IS TRUE ABROAD AS WELL AS HERE.

It seems to be a clear international engineering duty of both the Institutes of Electrical Engineers and the Illuminating Engineering Societies to establish a standard specification. At present the various ideas on the subject can be best stated as "many men of many minds." After reading carefully the reports of various national societies on the subject, it appears as if two main ideas were rising above the rest.

First—Specifications requiring actual foot-candle measurement of illumination on high intensity streets, as taken on, or referred to a plane, a metre above the street surface, and direct candle-power measurements on low intensity streets; such specifications to be properly qualified as to minimum and average illumination, location of light sources, longitudinally and vertically, to give the best arrangements for horizontal and vertical illumination.

Second—Specifications based mainly on the service to be given by the maintenance of light sources whose candle-power, consumption, etc., are established in the laboratory.

It is believed that both ideas should be used in making up a combined specification to cover the various forms of lighting as now practised, which will not only give us a basic standard of street illumination, but also cover the very important question of the illumination service to be given. The result of illumination and service, taken together, not separately, is what is paid for, and THE SECRET OF GOOD ILLUMINATION IS GOOD SERVICE.

C. F. LACOMBE,
Chief Engineer of Light and Power,
City of New York.

ILLUMINATING ENGINEERING AND THE ARCHITECT.

We would urge that scientific illumination should be considered much more seriously and thoroughly than up to the present it has been. The architect is, we know, a conservative individual, and does not readily take to the idea of co-operation in or interference with his designs. He has not yet reached the stage, except in a few honourable exceptions, where he realises that lighting is, after all, a specialised science, and should be treated by a specialist, but prefers to subordinate this most important sphere of activity to designs which while looking perfect on paper, and thoroughly effective in natural daylight, show themselves conspicuously defective when the scheme of artificial lighting which he suggests is applied to them. If the architect can once be brought to see that anything which gives an all-day and all-evening efficiency to the beauty and completeness of his architectural conceptions is really aiding his own interests, he will, perhaps, be more inclined to consider co-operations with the electrical engineer in the first stages of his design; but we fear that until a sufficient body of public opinion has been formed to discriminate between good and bad lighting effects this important subject will still remain outside the range of practical application. —*Electrical Review.*

NIGHT-WORK AND SPOILAGE OF MATERIALS.

In a recent article in the *Journal of the Royal Society of Arts* on the textile industry, reference is made to the difficulties of night-work. Men working during the night-time expect to be more highly paid, and experience shows that it is not the pick of the operators who offer their services.

It is added, "In the experience of some dyers more cloth was spoiled by the inefficient attention of night labourers during six months than in the preceding six years."

This spoilage may be due partly to indifferent labour. But is it not highly probable that it is in some measure the result of imperfect lighting conditions? And that the better class of work secured in the daytime may be accounted for by the fact that the natural illumination is so much more satisfactory than the artificial lighting conditions in many mills?

Mr. Franklin Thorp, in a recent paper at the National Gas Exhibition, remarked that in a well-lighted mill the turnover during the winter months (when artificial light was largely used) was quite as great as in the summer. Possibly, therefore, the experience of exceptional spoilage at night would be found to refer mainly to works in which the artificial lighting was not thoroughly up to date.

OBJECTIVE PHOTOMETRY.

By DR. W. VOEGE (Hamburg).

(Abstract of paper presented at a meeting of the German Illuminating Engineering Society in Berlin, March, 28th, 1914.)

FROM the very commencement of photometry a desire has been evident to replace the eye, as a photometric instrument, by some purely physical apparatus. The eye, notwithstanding its complete development as an instrument of vision, is open to several objections as a photometer. The experiences of various eyes are not the same, especially as regards the appearance of coloured surfaces, and even the impression received by one person may vary much according as the eye is "dark-adapted" or "light-adapted."

And yet it must be recognised that the eye is the only judge of the actual impression received by illumination in practice, and that we cannot depend *exclusively* upon physical apparatus which responds to radiated energy according to quite a different law. But it may be asked whether it would not be possible to retain the eye as the ultimate standard and yet make use of calibrated physical instruments for oft-repeated photometric measurements, which are apt to be tedious when carried out in the ordinary way.

VARIOUS TYPES OF "OBJECTIVE PHOTOMETERS."

At the present time there are three forms of apparatus applicable to "physical" photometry, the thermopile, the bolometer and the selenium cell.

As regards the thermopile E. and R. Pauli* have recently shown that it is inapplicable to practical objective photometry; Houstoun† has found that with the aid of a suitable light-filter agreement between the eye and the thermopile can be achieved within quite narrow limits. But the sensitiveness of the Houstoun apparatus is so slight that it cannot be regarded as a practicable substitute for the eye.

Great hopes were founded on the selenium cell. Its use in photometry was suggested by Werner v. Siemens as far back as 1877.* But later experience has failed to enable a serviceable selenium photometer to be constructed. The sensitiveness of such cells to light and colour depends on quite a variety of factors. The point of maximum sensitiveness in the spectrum varies with the temperature. Exposure to white or blue light previous to use makes the cell more sensitive to red.

Even for the same variety of radiation some cells are found to have their maximum in the red, others on the green-yellow. Finally there are the troublesome effects of inertia, which likewise depend on various factors and are quite uncontrollable.

There remains the photo-electric alkali cell, which during recent years has been developed by Elster and Geitel† This has proved so good for photometric purposes that it deserves to be described somewhat fully.

THE PHOTO-ELECTRIC ALKALI CELL.

In such a cell there are two electrodes, separated by air, to which a suitable P.D. is applied. Then, if the negative electrode is exposed to a strong light, electrons are emitted, and as a result a small but measurable electric current will flow. This so-called "normal" photo-electric effect takes place with all metals, but increases with diminishing wave-length of the incident light. But in the case of the alkali metals there exists, besides this "normal" effect, a "selective" action, and for this effect the maximum sensitiveness is in the visible region of the spectrum. The maximum is located near 440 $\mu\mu$ in the case of potassium, near 320 $\mu\mu$ for sodium, and near 480 $\mu\mu$ for rubidium.

* Ann d. Physik, 1913, Bd. 41, p. 812.

† Phys. Zeitschr., 1911, v., p. 800.

* Wied. Ann. 2, 1877.

† Phys. Zeitschr. 1910, XI., p. 257.

This selective effect may be so marked that the normal effect is, in comparison, of small account.

Elster and Geitel have increased the sensitiveness of such cells substantially by allowing a discharge current to pass in an atmosphere of hydrogen.* In these circumstances a potassium surface becomes blue or violet, a sodium surface changes to a yellow or yellow-brown tint. At the same time the sensitiveness is much improved, but the colour gradually disappears in the presence of hydrogen and the cells are not constant. It is only when the hydrogen is replaced by argon that highly sensitive and constant cells can be obtained.

Advantages of Alkali Cell.

Such cells have a number of highly valuable qualities in photometry:—

They are very sensitive to weak light. They are practically free from inertia, and the photo-electric current is, within wide limits, proportional to the intensity of illumination. Thus, Elster and Geitel have found that in a sodium and potassium cell the proportionality exists from 10^{-4} up to 80,000 lux. Such cells have already been used with good results in some branches of photometric work, *e.g.*, for the recording of daylight variations, for measuring the density of photographic plates, &c. Yet they have not been applied to the testing of artificial sources of light. The chief reason is that the curve of sensitiveness throughout the spectrum differs considerably from that of the eye, the maximum being in the blue-violet. (See Fig. 1.) Hence the cells can only be applied to the comparison of sources having approximately the same spectrum composition. Richtmyer* has recently contended that the cells can only be used for monochromatic light. But this objection can be overcome by using a filter of such a colour that the transmitted light yields a new maximum situated at the same point as in the spectrum as that of the eye. After some experiments the author found that a solution of potassium bichromate and eosin in water gave the desired results.

This combined solution transmits only red, yellow and green, and absorbs all light beyond 528 $\mu\mu$.

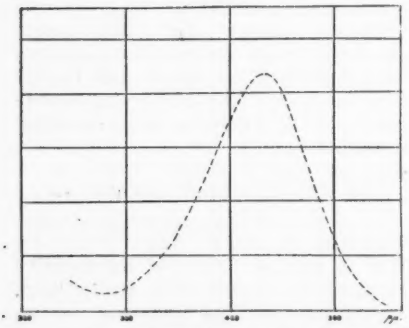


Fig. 1.—Curve of sensitiveness of ordinary cell without filter. The maximum is in the blue-violet.

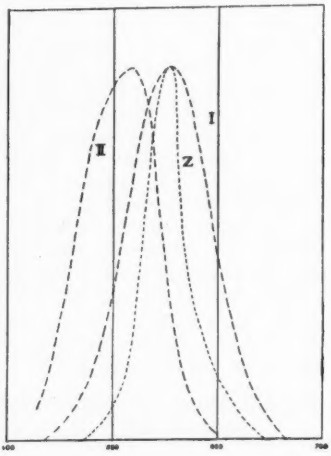


Fig. 2.—Curve of sensitiveness throughout the spectrum of—
I. Normal eye. II. Colour blind eye.
Z. Photo-electric cell.

In this way we obtain a curve of sensitiveness closely resembling that of the eye. In Fig. 2 we see side by side the luminosity curves for the normal eye (I) and for a colour-blind eye (II). The third curve (Z) is the curve of sensitiveness of the cell with filter in front. It is completely enclosed inside the curve (I) and has its maximum at practically the same point.

It will be observed that the curves (I) and (Z) are not identical and, therefore,

* Phys. Zeitschr. 1911, XII., pp. 609, 758.

* Zeitschr. f. Bel. 1913, p. 507.

while the results should be substantially in agreement for most continuous spectra, this may not be the case for line-spectra, such as that furnished by the mercury vapour lamp. Fig. 3 shows clearly

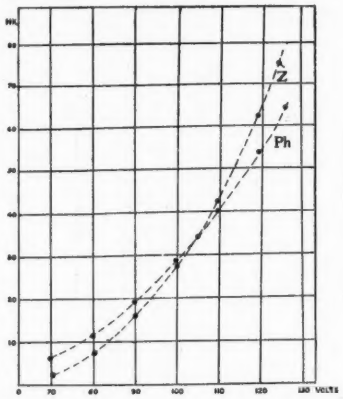


FIG. 3.—Comparison result obtained at various pressures for a glow lamp with a photometer (Ph) and a cell without filter (Z).

the need for the filter. The results obtained by the photometer and by the cell (without filter) are placed side by side. As might be expected, the cell gives too low a reading when the voltage is low and the red rays are accentuated, and too high a reading above normal voltage, when the blue component in the spectrum has increased. (In this and other data given the cell is assumed to give the right result when the lamp is operated at normal P.D.) When the cell was covered by the filter, several points on both curves were found to coincide.

PRACTICAL RESULTS.

The following tables contain data selected from a large number of observations. Table I. refers to a carbon and a metal filament lamp run at various voltages. The deviations between the results obtained respectively by the use of the cell and the photometer are negligible. The most marked variation is in the case of the metal filament lamp. At 135 volts the result from the cell was 4·3 per cent. higher than that measured photometrically. But by plotting the results obtained with the photometer in the form of a curve it was found that the value 50 H.K. was clearly wrong, and that it should be 52 H.K. In other words, the objective method was proved

TABLE I.

P.D. volts.	Cell. Deflection.	Cell. H-K	Photm. H-K	Diff. in results.
Carbon Filament Lamp.				
85 V	10·5°	5·85	6·0	—2·5%
90	13·5	8·53	8·57	—0·4
95	22·0	12·25	12·37	—0·98
100	30·5	17·00	17·06	—0·35
105	41·7	23·26	23·18	+0·35
110	55·6	31·00	31·0	±0
Metal Filament Lamp.				
110 V	18·4°	25·0	25·0	±0
115	21·8	29·62	29·60	+0·07
120	25·5	34·70	34·90	—0·57
125	29·5	40·10	39·7	+1·0
130	34·0	46·25	46·60	—0·75
135	38·5	52·3	[50·0 52·0	+4·3] +0·6

to be right. This is one of many cases in which the objective method has proved useful as a control in detecting incidental photometric errors.

In Table II. the results of some tests on a "half-watt" lamp are shown, two observers taking part. The difference in colour between the half-watt lamp and the "comparison lamp" was quite marked, so that some difference between the readings of the observers was to be expected. It will be observed that more consistent results were obtained by the use of the cell than by using the photometer; also that the readings of the second observer, both with the photometer and the cell, were somewhat lower, so that in all probability the lamp was giving somewhat less light. The mean results in the two cases (shown in the lower portion of the table) agree quite satisfactorily.

Table III. refers to various types of glow lamps. As these lamps were first tested on the bench and then removed to a holder mounted at a distance of 60 cms. from the cell, the errors of experiment are naturally greater. Nevertheless the results agree well. Even the photographic yellow coloured glow lamp and the Verico "daylight" lamp agree quite as closely when tested by the cell as they do when compared by means of the photometer. That the red and blue

TABLE II.

½-Watt Lamp, 100 K. 12 V.

P.D. Volts.	Photometer. 1. Obs.	2. Obs.	Mean.	Diff.	Cell. 1. Obs.	2. Obs.	Mean.	Diff. in Results.
10 V	51·0	51·4	51·2	+0·8%	28·0°	28·0°	28·0	±0 %
11	71·5	67·6	69·4	—5·6	40·0	39·2	39·6	—2
12	96	94	95	—2·1	54·4	53·4	53·9	—1·9
13	129·7	127·0	128·4	—2·1	72·0	70·8	71·4	—1·7
14	164	159	161·5	—3·1	93·6	91·3	92·5	—2·5
15	207	194·8	201	—6	115·7	113·6	114·7	—1·8

P.D.	Photm. Mean.	Cell. Mean.	Diff.
10 V	51·2	49·3	—3·6%
11	69·4	69·7	+0·4
12	95·0	95·0	±0
13	128·4	126	—1·9
14	161·5	163	+0·9
15	201	202	+0·5

rays have little or no influence on the impression of brightness has been shown in another way. A half-watt lamp was tested with the cell, in one case a blue glass being placed in front and in the other a bright yellow glass. The results, when tested by the photometer and cell methods, agreed almost perfectly in both cases. Therefore the cutting off of the rays at the left and right ends of the spectrum is without measurable influence.

TABLE III.

Various Electric Glow Lamps.

Lamp.	Photm.	Cell.	Diff.
Sirius Lamp (25 K clear)	27·5 K	27·5 K	±0 %
Carbon Filament Lamp (32 K clear)	32·4	33·0 / 32·6	+1·2
Carbon Filament Lamp (5 K clear)	7·3	7·7	+5·3
Carbon Filament Lamp (25 K frosted)	20·1	20·25	+0·75
Carbon Filament Lamp (5 K yellow)	4·65	4·82	+3·5
Tantalum Lamp (25 K frosted)	3·25	23·6	+0·44
"Verico" Lamp (80 K blue)	78	75	—3·9

Experiments were also carried out on the comparison of lamps of various kinds, petroleum, incandescent gas, metal filament, &c., a metal filament lamp being used as the comparison lamp throughout. (See Table IV.) The flame of the oil lamp burned irregularly, and the conditions of experiment precluded very exact conclusions being drawn. But it would appear that the figures for the incandescent gas, tested with the cell, are higher than they should be, and the corresponding values for the oil lamp too low.

TABLE IV.

Various Lamps.

Lamp.	Photm.	Cell.	Diff.
Metal Filament ..	27·5 K	27·5 K	±0 %
Petroleum (Round Burner)	14·4	13·5	—6·5
Inct. Alcohol	16·5	17·5	+6
Inct. Gas	32·1	34	+5·9
Inct. Gas	67·6	67·0	+0·9

Evidently care should be exercised in applying the method to lamps of entirely different colour. In the comparison of a mercury vapour lamp with a metal filament lamp a variation of as much as 40 per cent. was recorded, and there were also deviations in the case of flame carbons. But the degree of agreement shown in the tables referring to various glow lamps is surely a demonstration

that the method can be applied to lamps of the same class, and this is a result not previously attained with a physical photometer.

Technical Details of Method.

Something may next be said on the technical details of the apparatus.

As regards the light-filter it is naturally not convenient to use liquids in practice. But after some experience the author succeeded in obtaining from an English firm a gelatine filter which answered all requirements, and with which the above results were obtained. For many purposes, for example, for glow-lamps of the same type, one can use a more transparent variety of filter than that described above; this lighter filter would serve for metal filament lamps whose pressure was varied only between the limits of 105—120 volts.

The sensitiveness of the cell is naturally much diminished by the use of the filter, but fortunately one has, in the P.D. applied to the cell, a means of neutralising this diminution. Fig. 4

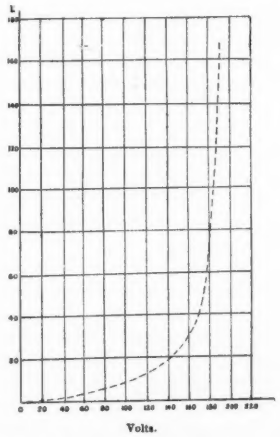


Fig. 4.—Showing rapid increase in sensitiveness with rising voltage.

illustrates the relation between the photo-electric current and the P.D. This rises first gradually and then more sharply. At 200 volts a luminous discharge in the cell would take place. This must at all costs be prevented by the use of an appropriate series resistance. 160 volts is about the safe limit, and it is best to confine oneself to the range of 60—150 volts, within which limits the desired sensitiveness can be obtained. Ordinarily the sensitiveness is most readily obtained by adjusting the distance of the lamp.

The measurement of the current is accomplished by the use of a mirror-galvanometer whose sensitiveness should be of the order $1°=10^{-9}$ amps. With such a galvanometer and about 70 small accumulators (in view of the small current taken the size of these is immaterial), the various measurements required in practice can be made. The distance of the cell naturally varies according to the power of the light-source. For example, a small hand lamp at a distance of 30 cms. will give a deflection of about 40 divisions. If the more transparent filter, intended for glow-lamps of the same class, is used, a galvanometer with a pointer and a sensitiveness $1°=10^{-8}$ ampère can be used.

The general arrangement of the apparatus will be understood from Fig. 5.

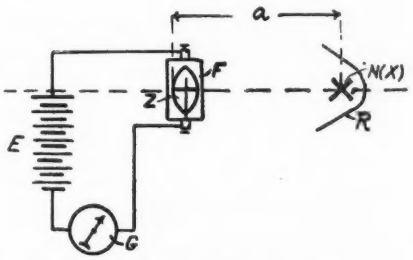


Fig. 5.—Showing arrangement of cell.
E Battery. Z Cell. F Filter.
G Galvanometer. N Source of light.
R Reflector.

The cell, *Z*, is connected in series with the galvanometer, *G*, and with a source of P.D., *E*. The effect of the lamp is conveniently accentuated by the white diffusing reflector, *R*. A standard lamp is now set up and its distance, *a*, from the cell so adjusted that the galvanometer reading is equal to (or a convenient multiple of) its actual candle-power. Finally the lamp to be tested is substituted for the standard lamp, and the reading of the galvanometer

will then read direct in candles. Naturally, the lamps can be rotated if desired, although the effect of the white background and the uniformity of metal filament lamps usually render this unnecessary.

Possible Sources of Error.

I now come to the possible errors and applications of the apparatus. The chief sources of error are :—

(1) Variations in sensitiveness of the cell. That the cells may vary in a space of months or years is naturally not impossible. But the author's own cells have undergone no appreciable variation, and Elster and Geitel regard the cells as practically constant. Richtmyer writes that his cells altered after exposure to an illumination of about 3,000 lux for half an hour; but such strong illuminations are not usual and should in general be avoided. In any case these sources of error can be eliminated if the cell is calibrated by reference to a standard lamp before and after the experiment. And for such a short period as a single day the constant would surely remain unaltered.

(2) There are certain possible errors due to processes taking place within the cell, *e.g.*, an appreciable current in darkness, inertia, radioactivity, &c., which betray themselves in experiments in a very feeble light with the electrometer. But these only give rise to currents of the order of 10^{-13} or 10^{-16} amp. and have no influence on measurements with lamps.

(3) The series resistance should not be so large as to be comparable with that of the cell itself. As the galvanometer has ordinarily a resistance of several thousand ohms, the series resistance is not usually necessary.

(4) The dimensions of the filter in relation to the cell should not be too small, since in this case lamps of various sizes, at different distances, will not be screened to the same extent.

(5) The P.D. of the accumulators should be constant. Since such an exceedingly small current is taken, this should be the case. (The supply mains should not be used!) This source of error may safely be ignored.

Applications of the Method.

The applications of the cell may be briefly summarised as follows :—

(1) For the measurement of electric glow-lamps of all kinds.

(2) For the photometry of incandescent gas burners.

As a comparison lamp either an incandescent burner or a metal filament lamp may be used. The method is particularly convenient for regulating the source to give a certain candle-power.

(3) For the testing of small hand-, pocket-, or mine-lamps. In determining the useful life of such lamps one merely stations them at a convenient distance from the cell and observes when the deflection has diminished by 20 per cent. from its original value.

(4) For relative measurements of every kind, *e.g.*, in determining polar curves of light distribution, the influence of globes and reflectors, &c. In such cases the cell is used in the same manner as I have previously advocated for the thermopile.* The saving in time and labour in this class of work should be considerable. (For example, several curves for a Nitra lamp were obtained in scarcely half an hour.)

The cell has three distinct advantages over the thermopile : (1) One is dealing with the effect of actual luminous surfaces, and there is no necessity to take elaborate precautions to exclude the heat rays. (2) In view of the high P.D. (100 volts) employed slip-contacts and the like can be used, whereas in the case of the thermopile all moving surface resistances must be carefully avoided, and (3) The cell is practically free from inertia.

There are also special cases in which the objective photometer can be used with special advantage in the laboratory. There is no doubt that the cell itself, as well as the methods of using it, may be further improved. A certain degree of care must naturally be used, as in all photometric measurements. Whoever takes up this method without any experience of photometric and physical measurements may naturally make mistakes, just as they would with ordinary photometric appliances.

* Elektrot. Zeitschr., Jan. 16th, 1908.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

LIGHTING OF RAILWAY CARRIAGES AND PUBLIC VEHICLES.

FURTHER CONTRIBUTIONS TO THE DISCUSSION AT A MEETING OF THE SOCIETY ON APRIL 7TH, 1914.

MR. JOHN DARCH (*communicated*) :—

MR. KILBURN SCOTT, in opening the discussion on the above subject, published in last month's journal (p. 246), has given us a very excellent and comprehensive dissertation upon the above subject; there are, however, some points to which attention should be drawn and some practical suggestions in accordance with them that might prove serviceable.

GLARE.

Mr. Scott's references to the evils of glare were somewhat indefinite, and the so-called "shades" to which he and others referred and which figured so prominently in the photographs did not receive the condemnation which they deserved.

There is a general notion that if we can modify the intensity of the piercing filament by means of a glass shade we have done all that should be expected of us; but to spread this fraction of an inch of brilliancy over some 30 visible inches of "shade" is but to exchange the keenness of the razor for the massiveness of the axe. The glare is still there, but *in extenso*.

Let us realise that in the art of illumination the consideration of violent and destructive contrasts are of vastly greater importance than the choice of any actual degree of illumination. We seem to forget Fechner's law, that sensation is relative and not absolute. Any illuminated area, such as printed matter on the wall of a carriage or in the hand, with a surface brightness yielding, say, 0·01 c.p. per sq. inch, would be comfortably and readily visible in all its detail as long as that surface remained the brightest before us; but if we admit into the field of vision the usual sparkling glass "shade," or even the softer opal globe (seldom less bright than 0·3 c.p. per sq. inch or 30 times brighter than the object to be seen) the said printed matter or other object immediately becomes darkened and indistinct. To meet this difficulty by increasing the initial illumination is bad economy, for Fechner shows that increase of sensibility, *i.e.*, the gain, is in but logarithmic ratio to the increase of illumination, *i.e.*, the cost. It is therefore of the first importance, both to eyes and pocket, to provide for visual efficiency by the proper adjustment of contrasts;

after this, to provide for a sufficient illumination as expressed in foot-candles.

Let anyone try the experiment of looking into a well-lit carriage, say from without, from a point where the lights cannot be seen, noting well the detail of the interior and its occupants, then compare that view with one from a point where the lights are visible and a clear, pleasing sight will be changed into one of indefiniteness with a troubled effort for discernment.

A glass bell "shade" that exposes the bare filament, so commonly met with in carriages, is a self-condemned anomaly, for it shades nothing, and yet it is recommended, as "local 'shaded' lights" on p. 249, Fig. 4, in last issue.

The form of "shade," however, that seems to give more satisfaction to the railway lighting engineer is the enclosing globe, and this should stand condemned for its excessive wastefulness, in addition to its failure as a real shade; for not only is there the usual loss of 15 per cent. to 60 per cent. of light by absorption, according to the nature of the glass, but an enclosing globe depletes on the whole spherical flux of 12½ times the M.Sph.C.P. How much more reasonable to abolish the upper part above A B, Fig. 1 and to let two-thirds of the light (or 8 times the M.S.C.P.) go free to a dead white ceiling

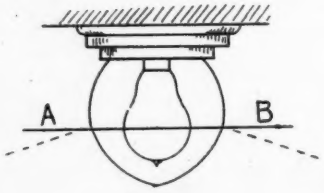


FIG. 1.

for useful diffusion and thus avoid waste; then to increase the opacity of the lower portion until it is of the same or less brilliance than that of the ceiling and thus increase the capacity for vision. That would be doubly economical.

BRACKET LAMPS

seemed to find favour during the evening's discussion; but those which we have so far seen in public vehicles, and those shown in Mr. Scott's sketch, p. 249, lie too low and must cause annoyance to those sitting opposite.

If bracket lamps are used they must be clear of a passenger's headgear when

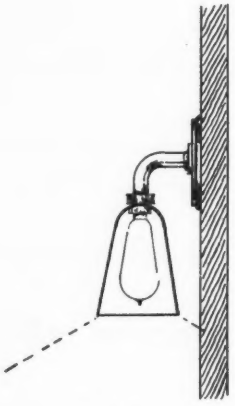


FIG. 2.

he rises and must have an absolutely opaque shade of the form of Fig. 2, and be used in addition to ceiling general lighting.

In the case of the usual compartment coaches each lamp might be made to do double duty and to entirely abolish the risk of obstruction to hats by being placed in the partition, and thus serve two compartments as Fig. 3.

INDIRECT LIGHTING

with opaque reflectors is hard to beat, providing the railway company can afford to provide energy enough to give 5 or 6 foot-candles on the passengers' books; but to be successful it needs a lofty type of carriage and the ceiling must be *kept* white.

There are, however, some economies and improvements that may be effected in this form of lighting. When a ray of light strikes a surface as A, Fig. 4, it is reflected at a like angle B, and that is strictly the case with glossy surfaces; but in Mr. Scott's sketch (Fig. 3, p. 248, in last issue), the ray is shown to be reflected in the direction D. It may be correctly argued that a dead white ceiling gives a diffuse reflection and

that therefore something will be reflected in the required direction, D, but it must not be forgotten that in all painted and papered surfaces there is a large

reflection to the spot required? This can be done by the simple process of curving the ceiling *in the same direction as the seats* as shown in Fig. 6. The

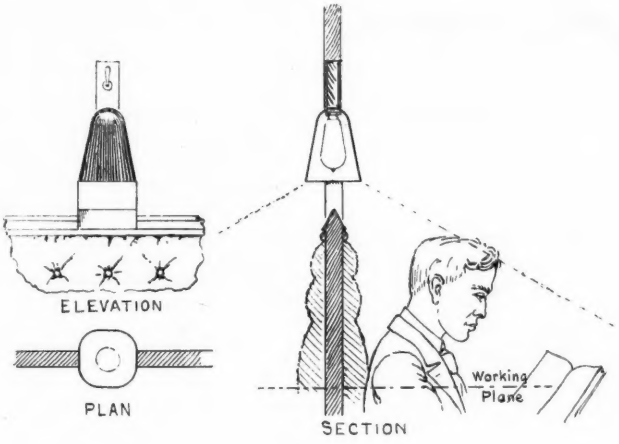


FIG. 3.

excess of regular reflection, as shown in Fig. 5, in which most of the ray A goes in the direction E, while

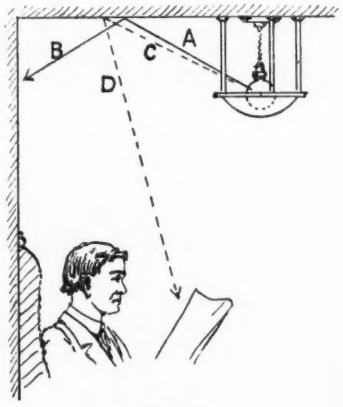


FIG. 4.

that in the required direction, F, is very feeble. Now, at that rate, it would need a prohibitive quantity of initial light to produce even a modest illumination on the reading area. Why not form the ceiling so as to direct the correct curve may be found by working out a series of tangents each being at right angles to a line bisecting the angle formed by the incident and reflected

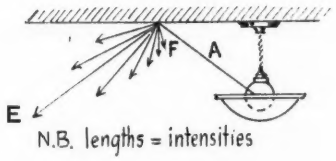


FIG. 5.

rays. In this fig. the curve is broken at A for the sake of head room, otherwise it would continue down to B.

A SHADED LIGHT SCHEME,

which combines the features and advantages of both direct and indirect lighting without their disadvantages, is herewith submitted. It is applicable to any type of carriage, but the compartment carriage only is illustrated in Fig. 7. The lights are placed on the ceiling, which, as Mr. Scott remarked, is the natural place, but at the side, out of the way of tall hats and where the light can fall at a convenient

angle on the readers' papers. Bare lamps should be used and may be tilted to benefit by the maximum radiation from the lamp. The controlling feature is the special type of shade used and when in this position should be semi-cylindrical as Fig. 8, and no larger than necessary to screen the lamp from the eyes of passengers inside or outside the carriage. It will be seen that by this arrangement the whole of the ceilings, walls, and working plane are flooded with direct light through 320° out of the 360° of the circle, excluding only the segment marked A (Fig. 7), while the whole is softened and augmented by the diffuse indirect light from the ceiling. The shades may be opaque and act as reflectors, but preferably they should be not quite opaque and a warm colour. The ceiling should be dead white. Four 40-watt lamps should give a brilliant and well-distributed illumination.

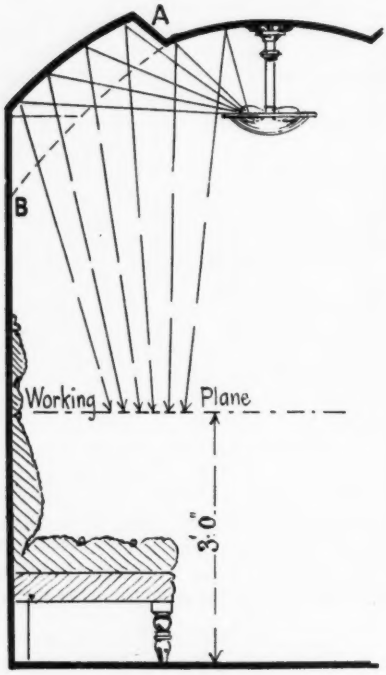


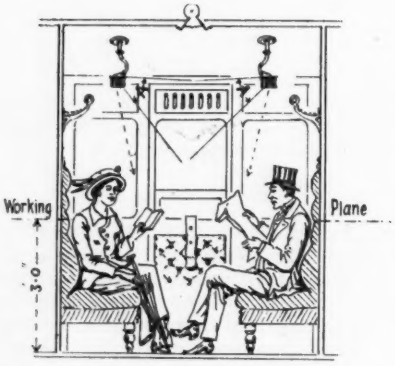
FIG. 6.

THE PROPER WORKING PLANE.

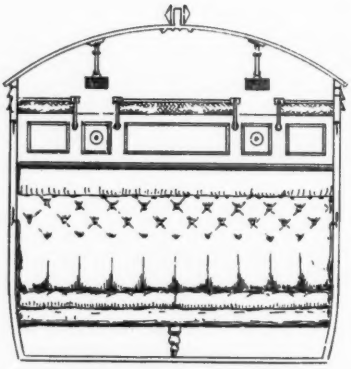
Mr. Roger Smith's choice of 4 feet from the floor—the level of the eye—and Mr. Dow's choice of the knees—2 feet from the floor—are both clearly wrong. The principal argument for light is for reading purposes, and it is neither the level of the eye nor of the knee, but that of the newspaper or book, that has to be considered, and that is, as nearly as possible, 3 feet from the floor.

INTENSITY OF ILLUMINATION.

I disagree with Prof. Morris and Mr. Dow that an illumination of 2 ft.-candles



CROSS SECTION
Light all round except angle A



LONGITUDINAL SECTION
Whole Side & Ceiling Illuminated

FIG. 7.

is sufficient in carriages or that 7 ft.-candles is objectionably high. Constant vibration gives a hazy effect to printed matter, while increase of illumination, by intensifying the contrast between ink and

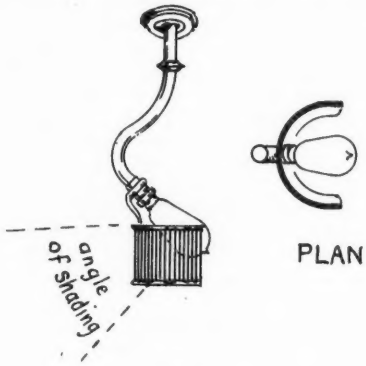


FIG. 8.

paper, renders perception easier. One could read without difficulty on the top of a rattling omnibus when it would be impossible in the comparative obscurity of the interior. Quite double the amount of illumination is, therefore, necessary in a vehicle to that in a room, in order to read with the same ease. Why else do passengers eagerly seek the brilliantly lighted carriages.

The degree of illumination necessary is limited, on the one hand, by the ability to read a vibrating book, and on the other hand by the cost of energy and not by fear of injury to the eye. It should certainly not be less than 4 ft.-candles—7 would be better. Dr. Steinmetz and others have shown how great is the range of intensity over which the eye can see with practically equal comfort. The trouble with high artificial illumination is not the legitimate illumination, which, properly diffused, might be 50 ft.-candles and do no harm; but the trouble is with violent contrasts, direct reflection, glare and sparkle, the lack of diffusion, and with the excess of heat rays in the commoner light sources, all of which irritate the eyes.

DECORATION.

I do not agree with Mr. Scott that with the use of bracket lights the ceiling may be dark. Diffusion is the essence of good lighting and is particularly necessary for the easy recognition of form. The ceiling should be a dead white in all cases, with a white frieze extending to, but not below, the hat rack. Below that level the eyes need the restfulness of something darker.

W. PERREN MAYCOCK (*communicated*):—

I notice that several speakers in the discussion on the Lighting of Railway Carriages and other Public Vehicles referred to the desirability of being able to vary the intensity of illumination. Mr. Kilburn Scott seems to have overlooked the fact that on long journeys most people like to doze or sleep. There are now available several arrangements of compartment switches for electric lighting which enable the lights to be modified in this way, and I anticipate that before long some of these methods will be introduced on some of the big railways.

LIST OF MEMBERS.

The List of Membership of the Society is now undergoing revision and will be issued shortly. Members are therefore requested to intimate any changes in address, etc., to the Hon. Secretary, during the month of June.

ANNUAL GENERAL MEETING.

(Held at the House of the Royal Society of Arts, London, W.C., on Thursday, May 21st, 1914.)

The Annual General Meeting was held at the House of the Royal Society of Arts on Thursday, May 21st, at 7.30 p.m., the President, Professor Silvanus P. Thompson, F.R.S., in the chair. The minutes of the previous meeting were taken as read, and the names of applicants for membership were read in the usual way.

THE CHAIRMAN then called upon THE HONORARY SECRETARY to read an abstract of the Council's report for the year. At the close of his remarks Mr. Gaster referred to the wide interest that the meetings of the past session had aroused, and stated that 1,500 visitors had been present during the five years the Society had been in existence.

MR. F. W. GOODENOUGH moved the adoption of the report. MR. EDWARD ALLEN seconded, and the report was then put to the meeting and adopted unanimously.

MR. F. W. GOODENOUGH said he had very much pleasure in moving the following resolution :—

> " That this meeting offers a cordial vote of thanks to Professor Silvanus P. Thompson for his services as President, and desired to express its great appreciation of his valuable services to the Society during his period of office."

This resolution, he said, needed very few words of his to commend it to everybody. They were indeed deeply indebted to Professor Thompson for the great interest that he had always shown in Illuminating Engineering, and they were also indebted to him for the skill and geniality with which he had always presided over the meetings. Professor Thompson combined in his presence a most extraordinary degree of omniscience, and a profound and peculiarly intimate knowledge of all branches of science and art, together with what was perhaps a somewhat unusual combination—namely, the possession of most business-like qualities in the conduct of Council meetings and the meetings of the Society. They all appreciated the amount of time that he had devoted to the work of the Society, and it was probably true in his case, as in so many others, that it is the busy man who finds the most time to give to work in which he is interested. Therefore the members did, as the resolution said, most heartily appreciate all the services that Professor Thompson had rendered to the Society during the years that he had been President. They were very sorry to part with him as President, but were glad to know that he was to be succeeded by a distinguished representative of the medical profession, and he hoped that for very many years to come the members would have the pleasure of Professor Thompson's presence at meetings, and the benefit of his ripe experience and advice.

MR. R. J. WALLIS-JONES said it gave him the greatest pleasure to second this resolution. As they all knew, Professor Thompson had from the very inception of the Society devoted an immense amount of time to its interests ; indeed, if it were not for the fact that Professor Thompson was, as he had been described by one of his most intimate friends, " a most desperate worker," he would never have been able to do as much for the Society as he had done. Professor Thompson had also proved a brilliant example of that old adage that there is a great deal more in the engineering of mind than in the engineering of matter, for in presiding at the Council meetings he had shown how diverse human elements could be brought together to work for the common good, and to form one homogeneous whole.

The resolution was put to the meeting and carried with acclamation.

PROFESSOR SILVANUS P. THOMPSON, in returning thanks for the vote, said he would make no attempt to assume omniscience, and he felt that a tribute of that kind was hardly merited. It was true he had been President for three

years, through the kindness of the members. At the same time he was afraid they had lately seen very little of him. But this he was glad to think that the Society had not suffered, because they had had such a very admirable Chairman in Mr. Goodenough. The members had now elected as President Sir William Bennett, and he had no doubt that under his fostering care the Society would flourish even more in the future that it had done during the last few years.

PROFESSOR THOMPSON added that, although withdrawing from the Presidency, he would always take a keen interest in the Society's work, and he hoped to be present at as many of the meetings as his engagements would permit.

MR. J. W. LIBERTY said he had very much pleasure in moving the following resolution :—

> "That this meeting extends a cordial vote of thanks to the Council and officers for their efforts on behalf of the Society during the past twelve months."

The thanks of the Society were due to the entire Council, but he might perhaps be allowed to make special mention of the Chairman of the Executive, Mr. Goodenough, and the Hon. Secretary and Assistant Secretary, Mr. Gaster and Mr. Dow respectively, who kept the members so well posted on events in the illuminating engineering world. The Council during the past year had extended the breadth of the platform of the Society, and discussions had taken place upon almost every conceivable form of lighting. He could only hope that this would continue to be extended if it were possible.

MR. G. CAMPBELL seconded.

The resolution was carried with acclamation.

MR. F. W. GOODENOUGH thanked the members on behalf of the Council. The work, he said, was entirely a labour of love, and if it had given satisfaction to the members, that was all the reward the Council hoped for.

MR. LEON GASTER also thanked the members for the vote of thanks on behalf of himself and the Assistant Secretary, and pointed out that it was only due to the harmony amongst the members of the Council that the work went along so smoothly. He did not believe there was in any other Society a Council containing such mixed interests as this one ; nevertheless members had worked together in a most cordial manner.

THE PRESIDENT proposed a vote of thanks to the Royal Society of Arts in the following terms :—

> "That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their room during the past session, and records its appreciation of the encouragement and support which the Society has received."

MR. HAYDN T. HARRISON, in seconding the resolution, said it was gratifying to find that the importance of the Illuminating Engineering Society had been appreciated and its work encouraged by the Royal Society of Arts, which had always been a pioneer in the study of lighting. He might mention that the degree of illumination in the meeting room had been considerably improved since the Society's meetings were held there, so that the Royal Society of Arts still continued to interest itself in the development of illumination.

THE PRESIDENT, in putting the vote of thanks to the meeting, recalled that the Royal Society of Arts was more than a hundred years old. Sir Henry Trueman Wood, the Secretary, had written a really delightful little book, on which an enormous amount of care and labour had been expended, describing the varied activities of the Society since it was founded.

One curious feature about the Royal Society of Arts was that it had always been glad from the beginning to lend its rooms for the purpose of other societies who took up particular branches of science, and the Illuminating Engineering Society was by no means the only one which had from its inception held its meetings in these rooms. There had also been many important industrial developments actually dating from such meetings. Early in the nineteenth century a meeting was held, at which the invention of Mr. Winsor in connection with gas lighting was described. The

first electro-magnet worthy of the name was shown by Sturgeon in *this* room, and on *this* table in 1825. It was here also that the possibilities of gutta-percha were first brought to the notice of the public. A lecture was given in these rooms in 1848 or 1849, at which young William Siemens, a young German engineer, was present, and he saw the possibilities of gutta-percha, and as everybody knew, he became famous subsequently in the improvements which he introduced into telegraphy and cables, largely by this means.

So one might go through almost the whole of the industries which depended upon science, and show how, from year to year, the Society of Arts had marked the progress of industry and invention by papers read and lectures delivered in this room. He had a very strong recollection himself of how, in the winter of 1882-3, he himself gave four lectures on the development, as it was then, of dynamo electric machinery, and there were various other lectures given at the same time on electric lighting. There had also been lectures on gas lighting, lighthouse lighting, and acetylene lighting, and the modern developments in gas lighting had been lectured upon by Professor Lewes in the course of a series of lectures. Therefore, as the Society had been so thoroughly identified for more than a century with industrial development, the Illuminating Engineering Society could not but gratefully recognise the opportunities they had had.

The resolution was put to the meeting and carried with acclamation.

THE CHAIRMAN then called upon Mr. A. P. Trotter to read his paper on "The Nomenclature and Definitions of Photometric Quantities." A discussion ensued, in which the following took part:—MR. E. ALLEN, MR. A. W. BEUTTELL, MR. W. J. A. BUTTERFIELD, MR. W. C. CLINTON, MR. J. DARCH, MR. K. EDGCUMBE, MR. F. W. GOODENOUGH, MR. HAYDN T. HARRISON, MR. W. J. LIBERTY, MR. V. H. MACKINNEY, PROF. J. T. MORRIS, MR. C. C. PATERSON.

Several communications to the discussion were also read, including contributions from DR. A. SCHUSTER (Secretary of the Royal Society), DR. LOUIS BELL (Boston), PROF. A. BLONDEL (Paris), and DR. H. BUNTE (Karlsruhe). Messages were also read from MR. J. SWINBURNE and DR. A. RUSSELL regretting that they could not be present, but expressing their general agreement with the views expressed in the paper.

MR. A. P. TROTTER briefly replied, and, on the motion of the Chairman, a very hearty vote of thanks was passed to him for his paper.

In closing the meeting the Chairman mentioned that the new session would open in November next, and that the date of the first meeting would be announced in due course.

[*A considerable number of contributions on Mr. Trotter's Paper have been received from corresponding members of the Society, and further communications are expected from many members who were unable to be present at the above meeting. We are therefore holding over this paper until our next issue, when it will be published with the complete discussion and Mr. Trotter's reply. At the same time it is proposed to reprint the original Report of the Committee of the American Society with which this paper deals.—Ed.*]

REPORT OF THE COUNCIL FOR THE SESSION, November, 1913—May, 1914.

(Presented at the Annual Meeting held at the house of the Royal Society of Arts, on Thursday, May 21st, at 7.30 p.m.)

In accordance with their usual custom the Council is issuing a Report of Progress during the present session.

The past year has again been fruitful in co-operation with other societies. One of the most important events has been the formation of the International Commission on Illumination and of National Illumination Commissions in several of the respective countries interested.

The Society has been represented at a number of important Congresses. Reference to some of these made in the Report of Progress during the vacation submitted by the Hon. Secretary at the opening meeting of the session in Nov., 1913.*

Increased Membership and Support.

During the past five years the Society has enjoyed the great benefit of Professor Thomson's experience and able guidance as President, and at the request of the Council he several times consented to continue in office at the end of the year. But now that the Society has passed through its initial stages and may be looked upon as firmly established, the Council has reluctantly acquiesced in his desire to be relieved of the Presidency, owing to the pressure of other work. The Council desire to place on record their appreciation of Prof. Thomson's great services to the Society.

During the past years the Society has covered very general ground, and in dealing with such a variety of topics the President's versatile knowledge has been invaluable. Now the Society is proceeding to the discussion of practical applications and the treatment of specific problems in more detail. One of the most important aspects of illumination at the moment is in relation to hygiene and eyesight, and it is essential, in dealing with this subject, to enlist the support of the medical profession.

* Illum. Eng., Dec. 1913.

As is well known, Sir William Bennett, K.C.V.O., F.R.C.S., has consented to accept the Presidency for the coming session, and presided at the Annual Dinner on Feb. 13th. The Society is extremely fortunate in having secured as its next President such an eminent member of the medical profession.

The Society has also added to its number several distinguished Vice-Presidents, including Professor Vautier, the first President of the International Commission on Illumination, and Sir Thos. Oliver, who is prominently connected with the subject of industrial hygiene in which illumination is now recognised to play an important part.

In view of the necessity of co-operation with kindred bodies, particularly those associated with the Society on the National Illumination Commission, a proposal was made by the Council to the Institutions of Gas and Electrical Engineers that their Presidents should be *ex officio* members of Council and Vice-Presidents of Illuminating Engineering Society. This invitation was accepted, and during the past year Mr. W. Duddell and Mr. E. Allen, the Presidents of these Institutions for the year, kindly consented to act in this way.

In recognition of his services as Chairman of Council during the past two years Mr. F. W. Goodenough has also been created a Vice-President.

It is with great regret that the Council records the death of one of our most distinguished Vice-Presidents, Sir William Preece, whose name is associated with some of the earliest work on the measurement of illumination, and who, from its commencement, took a keen interest in the work of the Society.

The membership of the Society has now increased to over 470—an increase of about 80 members during the year.

The following are the proportions in which the various interests are represented :—

Electrical Engineers and Members concerned mainly with Electric Lighting	36
Gas Engineers, Manufacturers of Gas Appliances, &c.	20
Professors of Physics and Engineering, Experts in Photometry, &c.	12
Representatives of Oil, Acetylene, Petrol-Air Gas Lighting, &c. ..	7
Physicians, Oculists, Opticians, &c...	8
Architects, Surveyors, &c.	5
Miscellaneous, including Public Lighting Superintendents, Mechanical Engineers, Makers of Shades and Reflectors, and others not exclusively connected with any one system of lighting	13
	100

The proportions are substantially the same as those presented at the last Annual Meeting. Fuller representation of the gas industry is still desirable, and it is also to be hoped that in the near future the number of members representing the architectural profession will be considerably increased.

Extension of Membership in the Provinces.

The events of the past year have illustrated the value of the international connection of the Society.

But for some time it has been felt that some effort should be made to increase the representation of the Society outside London. At the National Gas Congress and Exhibition in October, 1913, the suggestion was brought forward by Mr. R. G. Shadbolt that it would be of assistance for meetings to be held occasionally at certain centres in the provinces, so that those members who reside outside London might have an occasional opportunity of taking a more active part in the Society's gatherings.

It is hoped, when the representation of the Society in the respective districts has been strengthened sufficiently, that meetings devoted to topics of local interest will be arranged at each centre ; occasional opportunities will thus be provided for country members to meet friends from London, and to keep in closer touch with the Society's work.

The Council hope that before long it will be possible to arrange for special local meetings of this kind, and it is proposed for the time being to nominate representatives of the Society in some of the chief cities, who will assist in increasing the membership in their locality. Representatives have already been appointed in Glasgow, Manchester, Leeds, Liverpool, and other cities. Meantime it is hoped that members residing out of London will make a special effort to interest friends in the movement, so as to secure as soon as possible the necessary representation in their district.

Meetings of the Society during the Past Year.

During the past year seven meetings (including the Annual General Meeting) have been held. At the first meeting on Tuesday, Nov. 18th, 1913, a summary of progress during the vacation was again presented by Mr. L. Gaster. (A considerable amount of work is now undertaken during the vacation, and it is probable that these reports will be an annual feature.) Subsequently the Chairman of Council (Mr. F. W. Goodenough) gave a short address on Illumination at the National Gas Congress and Exhibition ; Dr. James Kerr presented an account of the proceedings at the Fourth International Congress of School Hygiene held at Buffalo during August, and Messrs. J. S. Dow and V. H. Mackinney read an illustrated paper on "Shadows by Natural and Artificial Light."

At meetings of the Society in the past two important points, the avoidance of glare and the provision of sufficient intensity of illumination, have been brought forward. The above paper was intended to demonstrate that there is a third factor, the direction of light and its effect upon shadows, which is also of consequence in illuminating engineering. It is well known that the conditions of shadow furnish one point of difference between daylight and artificial light.

The second meeting of the session, on Dec. 16th, 1913, was devoted to a paper by Mr. P. J. Waldram entitled "Some Problems in Daylight Illumination." The

paper had special reference to school lighting and discussed some of the problems now being considered by the sub-committee of the Society appointed to deal with this subject. The paper contained appendices by Dr. James Kerr and Dr. E. H. Nash, summarising recent Continental research. The sub-committee on Daylight Illumination in Schools also prepared a series of queries on this subject which were circulated among various authorities in this country and abroad, just as was done on a previous occasion when the Artificial Lighting of Schools was under consideration. The replies to this inquiry were collected and published in THE ILLUMINATING ENGINEER at the same time as Mr. Waldram's paper. This inquiry showed that there were many fundamental points on which very little is known, and that the Society, by instituting investigations into these matters, might render valuable services to the architectural profession. The discussion of Mr. Waldram's paper was resumed at a second meeting on Jan. 15th, when some further particulars of tests of the use of small models for predetermining daylight conditions in rooms were placed before the meeting by himself and Mr. W. C. Clinton.

The subject of discussion at the next meeting of the Society followed naturally after those at the previous meetings, dealing as it did with the distinction between natural and artificial light, as regards intensity, colour and shadow.

On Feb. 17th Professor Silvanus P. Thompson opened a discussion on the Lighting of Picture Galleries and Art Studios, dealing successively with the problems involved in daylight and artificial illumination. Several distinguished artists were present and joined in the discussion, and it was proposed that a Joint Committee should be appointed to carry these investigations further—a suggestion to which the Council mean to give effect.

At the next meeting, on March 17th, a paper was read by Mr. W. C. Clinton entitled "A Comparison of Estimated and Observed Values of Illumination in some Lighting Installations." The object of the paper was to show the possibility of calculating beforehand the illumination actually obtained in practice. In recommendations now being formulated for artificial lighting it is invariably found necessary to specify the amount of illumination required for certain purposes. It is therefore of fundamental importance to know how closely the illumination in a room can be predetermined in practice, and how far experience in one kind of interior can be applied to another. Typical installations lighted by gas and electricity, by direct and indirect lighting, &c., were studied, and it was shown that in each case the predetermined illumination was in substantial agreement with the value actually measured.

On April 7th a discussion on the Lighting of Railway Carriages and other Public Vehicles was opened by Mr. E. Kilburn Scott. In the course of the discussion photographs and data relating to carriages on some of the chief railways were presented, and representatives of several of the chief companies were present at the meeting. If may be mentioned that both this and the previous discussion received exceptional attention in the daily press, who are evidently looking to the Society for guidance in such matters.

At the Annual Meeting on May 21st the formal business is to be followed by a paper by Mr. A. P. Trotter on the Nomenclature and Definition of Photometric Quantities. In this case also corresponding members in various countries have been invited to express their views. It is proposed that the results of this discussion should be laid before the National Illumination Commission, and by them ultimately presented for the consideration of the International Commission on Illumination.

The Annual Dinner.

The Annual Dinner of the Society took place on Feb. 13th, the chair being taken by the President-Elect, Sir William Bennett, K.C.V.O., F.R.C.S.

The toast of "The Illuminating Engineering Society" was proposed by Sir Boverton Redwood, Bart., F.R.S.E., who summarised the chief achievements of the Society during its five years of existence, and especially emphasised the need for co-operation with the medical profession, coupling the toast with the name of the President-Elect. Sir William Bennett, in responding, expressed his appreciation of the way in which the

programme of the Society was being conducted, and said that the medical profession, as the guardian of the public health, was bound to take an interest in the question of good lighting. Experience in schools and factories demonstrated that good illumination was just as much a measure of true hygiene as ventilation or any other sanitary measure.

The toast of "Our Guests" was proposed by Mr. L. Gaster (Hon. Secretary of the Illuminating Engineering Society) and replied to by Sir William Crookes, F.R.S., O.M. (President of the Royal Society), Sir Henry Trueman Wood (Secretary of the Royal Society of Arts), and Mr. A. W. S. Cross (Vice-President of the Royal Institute of British Architects).

Among others who were present may be mentioned Mr. E. Allen (President of the Institution of Gas Engineers) and Mr. J. F. C. Snell (Vice-President of the Institution of Electrical Engineers).

The presence of these distinguished guests (most of whom were also Vice-Presidents of the Illuminating Engineering Society) was much appreciated, and the dinner was generally considered one of the most successful that the Society has yet held.

Joint Committees.

There are already in existence permanent Joint Committees on School and Library Lighting, which have issued interim reports. During the present year a sub-committee of the School Lighting Committee was appointed to deal with the subject of daylight illumination. This committee has also prepared an interim report which will be published very shortly. The experiments and investigations so far carried out lead to some valuable conclusions, but it is clear that there are many fundamental points of great importance on which further information is required. Besides their primary application to school planning such experiments are of considerable importance in relation to the access of daylight into buildings of all descriptions. Some of these researches are beyond the unaided resources of the Committee and it is hoped assistance from some outside quarter, such as the Educational Authorities, will be forthcoming.

The Council take this opportunity of expressing their appreciation of the very thorough work done by this Committee and would like to make special reference to the valuable services of its Chairman, Dr. James Kerr.

The Society is also represented on the Joint Committee composed of members of the Illuminating Engineering Society and the Institutions of Gas and Electrical Engineers, appointed to consider the preparation of the Standard Specification on Street Lighting. This Committee is still considering the Draft Specification presented by Mr. A. P. Trotter in his paper before the Illuminating Engineering Society last year.

It is probable that several other committees may be appointed as a result of discussions at recent meetings. The Council have in view the appointment of a Joint Committee, on which members of the Society, artists and architects will be invited to serve, dealing with the Lighting of Picture Galleries and Art Studios. It is also proposed to institute a general Committee on Research, which would promote experiments on individual points of interest that may suggest themselves in the course of the session.

As an instance of such subjects of research, the effect of glare from shiny paper may be mentioned. A committee of the American Illuminating Engineering Society has been studying this matter, and advocates the use of mat paper free from glaze, such as has been used for some time in that Society's *Transactions*. Members will be interested to observe that from the commencement of the present year THE ILLUMINATING ENGINEER, the official organ of the Society, has also been printed on paper of this description. In the United States the problem of testing and standardising the degree of gloss from papers has also been taken up. Some experiments in the same direction are being made in this country.

There will probably be other matters connected with the general welfare of the Society which the Council may desire to delegate to committees. In addition to those on Finance and Editing it is contemplated that a Committee on Extension of Membership and Local Representation will be formed, in order to deal with

matters arising in connection with the proposition to form local centres in provincial cities.

Finally there is the National Illumination Commission of Great Britain, formed during the past year, which constitutes a new outlet for the activities of the Society.

National Illumination Commission of Great Britain.

In the Report of Progress during the vacation (June–Nov., 1913) an account was given of the formation of the International Commission, which took place in Berlin last August. It will be recalled that at the International Electrical Congress in Turin in 1911 a resolution was passed unanimously approving the formation of such a Commission, at the initiative of our Society. It has now, happily, been found possible to form the Commission by suitably enlarging the membership and functions of the International (Zurich) Photometric Commission. The first step was the formation of provisional National Committees in the respective countries. After several meeting the British Committee reconstituted itself as the National Illumination Commission of Great Britain.

On this body the Institutions of Gas and Electrical Engineers are represented, and, through the Illuminating Engineering Society, other bodies interested in illumination. The representatives of the Illuminating Engineering Society are Prof. Silvanus P. Thompson (President), Mr. A. P. Trotter (Vice-President), Mr. F. W. Goodenough (Chairman of Council), Mr. L. Gaster (Hon. Secretary), and Dr. James Kerr.

The National Commission has the privilege of appointing two of its members to act as delegates to the International Commission on Illumination, and contributes to its maintenance £50 per annum. It has been arranged that each of the Societies represented shall pay £25 annually to the expenses of the National Commission, which will enable the Commission to meet the subscription referred to above, leaving an income of £25 per annum for local expenses.

The formation of National Commissions is being actively taken up in other countries. It is of interest to mention that in Germany it has been decided that the Illuminating Engineering Society in that country will act in this capacity.

Other International Developments.

During the course of the year the Illuminating Engineering Society in the United States has been very active. A number of interesting papers have been presented, particularly those at the Seventh Annual Convention held in Pittsburg last year. A new feature on this occasion was the presentation of a report on "A Year's Progress in Illuminating Engineering," which was subsequently reproduced in the official organ of the British Society. This report contains a valuable summary of illuminating engineering progress in Europe and America, accompanied by references, and will doubtless be of use to many members of the Society. Another feature has been the promotion of Joint Meetings with other bodies for the discussion of subjects of mutual interest—a plan which has been found to yield excellent results in the case of our own Society.

In the Annual Report for 1913 reference was made to the formation of the German Illuminating Engineering Society. During the past year a number of meetings have been held, and it is evident that the Society is growing in membership and influence.

The formation of Illuminating Engineering Societies in the various countries will do much to pave the way for international co-operation, and doubtless arrangements will be made for the Societies to be kept in close touch with each others' work. It has been suggested that certain papers should be discussed simultaneously by the three existing Societies, and that in the future more complete arrangements might be made to bring the respective transactions to the notice of illuminating engineers in other countries. In the case of the British Illuminating Engineering Society, the connection with its corresponding members in various countries has proved an invaluable means of ascertaining international opinion on current topics and finding a common basis of agreement.

An Illuminating Engineering Society has not yet been formed in France, but during the past year a new French

journal devoted to illumination, *La Science et Art de l'Eclairage*, has been issued under the direction of Prof. A. Blondel; this will doubtless prove to be welcomed as an authoritative source of information on developments in France.

Congresses during the past Session, &c.

During the past year there has been an exceptional number of congresses and meetings of other Societies, at which various aspects of illumination have been discussed; in several cases papers were presented by members of the Society. Most of these were dealt with in the Report of Progress during the Vacation, and only require brief reference here.

Thus at the International Medical Congress held in London at the beginning of August, papers were presented by two members of the Society, Mr. J. Herbert Parsons (in the section of Ophthalmology) and Dr. James Kerr (in the section of Hygiene and Preventive Medicine),dealing respectively with the "Affections of the Eye caused by Undue Exposure to Light," and the "Eyesight of School Children." Dr. Kerr was also present at the Fourth International Congress on School Hygiene held in Buffalo at the end of August, where he delivered a paper on "The Illumination of Classrooms." A feature of the Congress was the excellent plan adopted by the American Illuminating Engineering Society of making this a Joint Meeting, at which lighting engineers and medical officers could confer. Dr. Kerr presented a brief summary of the proceedings at this Congress at the opening meeting of the Society.

At the International Roads Congress held in London towards the end of June, a special section was devoted to road and vehicle lighting, and street lighting received special attention. This subject was dealt with more recently in a paper on "The Lighting of London" read by Mr. L. Gaster before the London Society on Feb. 10th. It is hoped that this will be the means of bringing the subject to the notice of municipal authorities.

It is of interest to mention two publications in the United States bearing on street lighting—namely, the Report on the subject presented at the Convention of the National Electric Light Association held in Chicago last June, and the paper read by Mr. C. F. Lacombe on Feb. 19th, before a joint meeting of the Municipal Art Club and the Illuminating Engineering Society in New York. This paper is of interest as showing the chief distinctions in the methods of illumination employed in European and American cities.

Mention should be made of the National Gas Congress and Exhibition which took place at Shepherd's Bush last October, where quite a number of papers relating to illumination were read. The proceedings at this Congress were summarised in Report of Progress during the vacation.

The Departmental Committee on Industrial Illumination.

The formation of this Committee early in 1911 was dealt with fully in the Council's annual report in that year. During the past session the Committee has been at work, and it is understood that visits to many factories have been made and some very complete data on industrial illumination collected.

The Report of H.M. Chief Inspector of Factories for 1912 again contained a considerable number of references to factory lighting, including a special report by Mr. D. R. Wilson on the Lighting of Iron Foundries. A number of measurements of illumination in foundries were recorded. The general method of treatment was similar to that followed in Mr. Wilson's corresponding report on industrial lighting in the previous year.

Additional Support Required.

The Society has again been able to carry out a considerable amount of useful work, and yet to keep its expenditure within bounds. The circumstances that render this possible were detailed in the Annual Report for 1912-13.

The arrangement by which THE ILLUMINATING ENGINEER acts as the official organ enables the Society to publish its transactions, the cost of which would otherwise be prohibitive. The Society has also been fortunate in not being called upon to meet many customary expenses, such as rent of offices, secretary's salary, &c., and its officers, in an honorary capacity, have ungrudgingly devoted much time to its affairs.

The Council having decided that the balance sheet of the Society should be audited annually by a Chartered Accountant, Messrs. Cash Stone & Co. were appointed, and have examined the balance sheet up to the end of 1912, which has been passed by the Council.

At the same time the growing activities of the Society make the present arrangement somewhat burdensome, and its future work may be hampered unless more ample funds can be placed at its disposal. A substantial increase in membership is still necessary to enable the Society to extend its activities, and the Council desire to emphasise the importance of securing additional members.

The Council consider that additional funds are needed to enable the work of the Society to be carried on in a satisfactory manner. It is laid down in Article 23 in the constitution of the Society that "any member may commute or compound for all future payments and become a member for life, by payment of a sum of not less than £10 10s. (ten guineas)." It is hoped that a number of members will take advantage of this method in order to provide additional funds. The Society has now a record of valuable work behind it, and its usefulness is beyond dispute. It may therefore reasonably expect that those who benefit by the movement will give their aid, and enable it to extend its present sphere of work.

Programme for the Next Session.

The Council is now engaged in considering the programme for the next session. Members who are willing to read papers are invited to notify the Hon. Secretary as soon as possible, and to send in contributions early in the vacation.

A list of suitable subjects (which, however, is not regarded as exhaustive) will be found in the Appendix.

The Council takes this opportunity of inviting any further suggestions as to the future work of the Society, or any subjects which might receive special attention during the next session.

By order of the Council,

LEON GASTER,

Hon. Secretary.

APPENDIX.

LIST OF SUGGESTED SUBJECTS ON WHICH PAPERS ARE INVITED.

1. New forms of instruments for measuring light and illumination and new apparatus for use in the photometrical laboratory. Methods of testing colour. Methods of testing the steadiness of sources of light.
2. Fixture design: the compromise between artistic and illuminating principles.
3. Decorative lighting and illuminating engineering from the standpoint of artistic effect and architectural principles.
4. The measurement of daylight and its application by the architect to designing window-space, and the access of natural light to interiors. The value of photometry in deciding ancient light cases.
5. Simple methods of calculating beforehand the distribution and intensity of illumination in interiors.
6. Instruction in illuminating engineering: Courses of lectures and laboratory work, &c.
7. The benefits of good illumination from the insurance standpoint, and as a means of preventing accidents.
8. Specific problems in the lighting of factories and workshops.
9. Illumination and portable safety lamps for mines, &c.
10. Modern methods of lighting and illuminants employed in ships, lighthouses, buoys, coast-lights, beacons, &c.
11. The use of light for advertising purposes, illuminated signs and devices, illuminated placards, billboards, notices, &c.

12. The production of light of various colours, and the best means of modifying the spectra of artificial illuminants so as to resemble that of daylight.
13. Problems encountered in the lighting of museums, picture galleries, &c.
14. The decorative lighting of parks, avenues, and flower gardens, fêtes, &c.
15. The physiological aspects of illumination, and the effects of artificial light on the eyes.
16. The correct application of light in projection, searchlights, lanterns, cinematographs, &c.
17. The lighting of billiard tables and other indoor games.
18. The artificial illumination of athletic grounds, tennis courts, skating rinks, bowling alleys, &c.
19. Country house lighting by private electrical installations, by acetylene, or by petrol air-gas and incandescent oil vapour.
20. Theatre lighting: Illumination on the stage and its use to produce scenic effects, &c.

NEW MEMBERS OF THE SOCIETY.

THE names of applicants for membership read out at the previous meeting of April 7th were read again at the last meeting on May 21st, and these gentlemen were formally declared members of the Society.*

In addition the names of the following gentlemen have been duly submitted and approved by the Council and were also read out by the Hon. Secretary at the last meeting:—

Vice President—

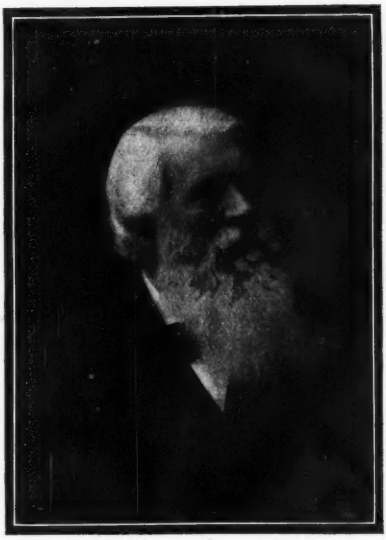
Oliver, Sir Thomas, *M.D., D.Sc., LL.D., F.R.C.P., F.R.S.Ed.*	Prof. of Medicine in the University of Durham, late Medical Expert Home Office Committee on Dangerous Trades. Chairman of the Section on Industrial Hygiene at the Annual Congress of the Royal Institute of Public Health, 1913. 2, Ellison Place, NEWCASTLE-UPON-TYNE.

Ordinary Members—

Jones, A. L.	Designer and Member Illuminating Engineering Section, Osram Lamp Dept. General Electric Co. 238, Upper Street, Islington, LONDON, N. (2)
Merz, C. H.	Consulting Engineer to Electric Power, Lighting, Railway and Tramway Undertakings in England, the Colonies and abroad. 32, Victoria Street, LONDON, S.W. (2)
Nash, Dr. E. H.	Medical Officer of Health. Town Hall, Wimbledon, LONDON. (2)
Simon, H. F., *A.M.I.E.E., A.C.G.I.*	Managing Director, Electrical Installations Ltd., 27, St. Martin's Lane, Cannon Street, E.C. 4, Wynnstay Gardens, Kensington, LONDON W. (2)
Styles, W. E., *A.M.I.E.E., M.A.M.E.E.*	Electrical Engineer, Lecturer and Instructor Electrical Distribution and Wiring, S.W. Polytechnic. 91, Forest Drive West, Leytonstone, LONDON, N.E. (2)
Thorpe, F. W.	Fixture Designer. 18, Birley Road, Totteridge Lane, WHETSTONE. (2)
Trezise, J. M. G.	Post Office, Engineering Dept. Superintending Engineer London Power District. 2, Colinette Road, Putney, LONDON, S.W. (2)
Turnbull, A. W.	Supt. Carriage and Elect. Lighting Dept., S.E. & C. Railway. 34, Greenhill Park, Harlesden, LONDON, N.W. (2)

* *Illum. Eng.*, May, 1914, p. 245.

SIR JOSEPH WILSON SWAN.



Born Oct. 31st, 1828.—Died May 27th, 1914.

It is with deep regret that we record the death of one of the great figures associated with the beginnings of the electric light in this country. On May 27th, Sir Joseph Swan died at his residence in Surrey at the advanced age of 85. The name of Swan will always be associated with the earliest experiments on the electric incandescent lamp, on which he was already carrying out researches in 1860, but which first became known to the nation at large about 1880. From that time onwards Sir Joseph was responsible for many inventions in this field, and up to the very last he was busily engaged in his scientific researches.

While the invention of the incandescent lamp is the most famous of his achievements, Sir Joseph Swan was also responsible for advances in many other directions, such as mining lamps, accumulators, and photography. In 1904 his distinguished services to science were honoured by a Knighthood and by the award of the Hughes Medal of the Royal Society.

Sir Joseph Swan was one of the original Vice-Presidents and was nominated an Honorary Member of the Illuminating Engineering Society in 1910. When the writer first approached him prior to the formation of the Society, Sir Joseph not only listened to his plans sympathetically, but in his kindly way made some wise suggestions. He was particularly anxious to point out that illumination was not a purely engineering matter and that the assistance of all sections of the public should be invited. Although his advancing years prevented him being present at meetings his occasional letters were full of interest in the Society's work.

Above all, those who knew Sir Joseph Swan were impressed by his simple, genial and lovable disposition, and there will be many, in all branches of science, who will hear of his death with keen personal regret.

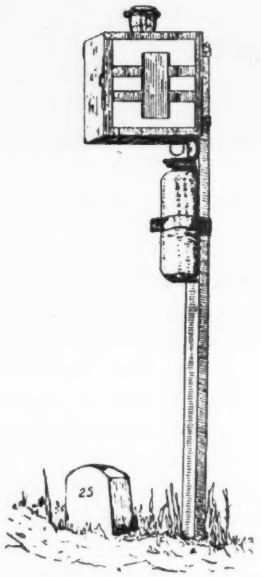
Leon Gaster.

SHORT NOTES ON ILLUMINATING ENGINEERING.

ILLUMINATED DANGER SIGNALS ON THE ROADWAY.

In a recent number of the *Journal für Gasbeleuchtung* an account is given of some illuminated sign-posts which are being put up in Germany in order to draw the attention of motorists to level crossings, obstructions in the roadway, &c. The illustration shows a sketch of one of these signs. This is illuminated by an acetylene jet provided with an automatic flashing device, the usual arrangement being a bright interval of ·3 seconds followed by a dark interval of ·7 seconds. It is stated that with a dissolved acetylene outfit one of these signs will last 30 days without attention, and that the daily cost should not be more than about 3 pfennigs (2½d.). The initial cost of each installation is stated to be 100 marks (£5).

We learn that the Road Board in this country is also interesting itself in this problem of providing signals for motorists. It appears that the first of these beacon lights has been erected on the London and Folkestone road near Sidcup, and it is probable that in future similar lights will be put up to indicate dangerous turnings. If the experiments prove completely successful, hundreds of these twinkling lights will soon be scattered throughout the country.



Sketch of Road-sign, fed by dissolved acetylene and equipped with flashlight apparatus. It is stated that a light operated in the way described above will last for about 30 days.

AN INTERESTING FORM OF INDIRECT PORTABLE UNIT.

The illustration shows a room in the Hyde Park Hotel, Chicago, where Curtis Portable Lamps have been installed.

This method of lighting was described in an article by Mr. Leonard V. Jones in a recent number of the *Electrical Review and Western Electrician*, to whose courtesy we are indebted for the photograph. It will be seen that the lighting is essentially an indirect one. But the pedestal fixture, while directing the majority of light on the ceiling, also allows a certain amount to come down under the silk shades, thus providing local illumination for reading.

It is stated that this design has also been adopted for table lighting, piano lamps, &c. The effect seems to be decidedly novel, and the fitting is an ingenious expedient for removing the impression of "flatness," sometimes complained of in the case of pure indirect lighting. It would appear, however, that some care in the design would be necessary in order to avoid a patchy appearance on the ceiling.

HELPING THE BLIND.

"Prevention, as well as Alleviation."

SUNDAY, May 10th, was made the occasion for thanksgiving services in all the churches of the country for "The Blessing of Sight," and on June 18th an International Conference on the Blind is to be opened at the Church House, Westminster.

The movement is one with all will find themselves in sympathy. It is gratifying to feel that illuminating engineering is also playing its part towards removing one of the preventible causes of blindness. Among the instructions to parents issued by the Union of Societies for the Blind there is one as follows :—

"Never allow your children to use their eyes in the twilight or by insufficient light, or they will become weak and short-sighted."

There is every reason to believe that in a considerable number of cases blindness is hastened, or even caused, by the strain following unsatisfactory lighting conditions.

In the factory, workers engaged in processes involving the inspection of fine details (engraving, lace-making, printing, &c.) will surely suffer if the light is insufficient. And in the schoolroom the very best illumination is needed. If the newer generation start under more favourable conditions as regards eyesight the percentage of blind people will steadily decrease.

It may be hoped, therefore, that at the coming congress the *prevention* of blindness as well as its alleviation will be considered. This is surely a case in which the physical and the physiological aspects of the subject should be considered together.

LIGHTING OF PARLIAMENT SQUARE AND THE PARKS.

THE *Sanitary Record* for April 3rd has an article reproaching the Office of Works for their lethargy in public lighting. For some time, it says, the lighting of the space adjacent to the Houses of Parliament has been regarded as insufficient. However, a number of lamps have been converted to inverted burners, giving an increased candle-power, and this is a sign that changes are contemplated.

It is also pointed out that the lighting of Hyde Park might with advantage be improved; by converting many of the existing lights to inverted burners a fourfold increase in illumination might be secured. The same applies to St. James' Park. The lanterns in Trafalgar Square have little effect owing to the surrounding much more powerful lamps. These, too, it is suggested, should at least be converted to inverted burners.

We agree that in many such cases an increase in illumination is desirable. But this is surely but a step towards what is necessary. The complaint has been made that the lighting of Trafalgar Square, for example, is too heterogeneous ; some consistent scheme throughout is needed. Again, we doubt whether these fine iron lanterns are shown to the best advantage by bright sources in clear glass. The method used in some of the American parks, of surrounding the sources with white diffusing glass, gives a much softer effect. It would be interesting to try the effect of substituting white glass and at the same time increasing the candle-power in some of the lanterns in Trafalgar Square.

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

The Elementary Principles of Illumination and Artificial Lighting. By Arthur Blok. (*Scott, Greenwood and Son, London,* 1914. 234 *pp.*, 126 *illustrations.*)

IN the preface to this work Mr. Blok states that it is intended mainly for the use of students and engineers interested in lighting, and that the numerical calculations have been presented in as simple a manner as possible.

Indeed, we think that the two chapters devoted to Illumination Calculations form the most valuable element in the book, the diagrams being clear and easily followed and the worked examples of various lighting problems distinctly helpful.

In the earlier portion of the book the units and standards, and the chief laws of illumination concisely explained and a list of symbols and equations used is given at the commencement. Subsequently there are chapters dealing with photometry, the derivation of polar curves and the measurement of illumination. There is also a chapter of Shades, Globes and Reflectors (in which the author reproduces, among other matter, a series of diagrams recently published in an article in the *Illuminating Engineer*), and a discussion of the general principles of indoor and outdoor illumination. The concluding chapter deals very briefly with the chief illuminants.

The treatment of polar curves of light distribution strikes us as particularly good. The author summarises on one page the curves of a number of typical illuminants showing how great is the diversity in practice, and the ineffectiveness of trying to compare illuminants on the basis of the candle-power in a single direction. Mr. Blok makes considerable use of the conception of flux of light. The book should be a serviceable one to students of illuminating engineering.

SOME PUBLICATIONS RECEIVED.

Interim Report of the Library Association Book Committee. (*Published by the Library Association, Caxton Hall, Westminster, S.W.*)

The Chadwick Public Lectures on Housing. By W. E. Riley, F.R.I.B.A. (*Published by "The Builder."*)

Types of Abnormal Colour Vision. By Dr. Louis Bell. (*Reprinted from the Proceedings of the American Academy of Arts and Sciences.*)

DOMESTIC LIGHTING, HEATING, AND COOKING.

A paper on "The Problems of Domestic Lighting, Heating, and Cooking from the Woman's Point of View" was read at a meeting of the Institute of Sanitary Engineers on Wednesday, April 1st, by Mrs. M. A. Cloudesley Brereton, and is reproduced in the last number of the Journal of the Institute.

Mrs. Brereton's lecture was illustrated by plans of a number of typical dwellings, and special reference was made to the difficulties introduced by basement premises and the necessity for special arrangements to secure adequate heating and lighting. Mrs. Brereton also described in detail how the heating and lighting of the modern kitchen department should be carried out. An important point was that in the modern house, the design of the house and the lighting and heating arrangements should be considered simultaneously. An interesting discussion ensued, in which Mr. Leon Gaster and Mr. F. W. Goodenough and others took part.

FORTHCOMING CONGRESSES.

THE ROYAL INSTITUTE OF PUBLIC HEALTH.

Annual Congress.

THE Annual Congress of the Institute will take place at Edinburgh from Wednesday, July 15th, to Monday, July 20th. Full particulars as regards travelling and hotel accommodation can be obtained from the Secretary, E. L. Ryley, Russell Square, London, W.C.

We also take this opportunity of drawing the attention of our readers to a course of Lectures on Industrial Hygiene by Sir Thomas Oliver which will commence on Wednesday, May 27th. The course will take place in the lecture room of the Institute, at five o'clock, and full particulars can be obtained on application. Sir Thomas Oliver's name is well known as an authority on this subject, and the lectures will doubtless appeal to a wide circle.

THE INSTITUTION OF GAS ENGINEERS' ANNUAL MEETING.

The Annual Meeting of the Institution of Gas Engineers will be opened in Liverpool on Tuesday, June 16th. We understand that an attractive programme has been arranged, and many matters of vital interest to the gas industry will be discussed. It will be recalled that the President on this occasion will be Mr. Edward Allen, whose name is also familiar to readers as a Member of the Council and Vice-President of the Illuminating Engineering Society.

Full particulars of the arrangements at the meeting can be obtained from the Secretary of the Institution of Gas Engineers, 32, Victoria Street, Westminster, S.W.

THE GAS EXHIBITION IN MUNICH.

An important exhibition dealing with the production and use of gas is to be held in Munich during the month of July. The programme promises to be of exceptional interest. The exhibition is divided into fourteen sections. Section 5, on gas lighting, is again subdivided into two main divisions, indoor and outdoor lighting. The former will contain sections dealing with minerals and processes used in mantle manufacture, burners, lamps, distance lighting and automatic ignition, typical gas lighting installations (halls, lecture theatres, &c.), and shop lighting.

In addition there is a section dealing with the use of gas in the home and school, and a collection of exhibits illustrating the production and use of various special forms of gas (oil gas, Blau gas, acetylene, air-gas, &c.). Yet another novel section is that dealing with the use of gas in connection with aeronautics.

Those interested in the exhibition should communicate with Dr. Schumann, 148, Dachauerstr., Munich (39).

THE SECOND INTERNATIONAL KINEMATOGRAPH EXHIBITION.

(*Olympia, August 29th to September 10th.*)

Those interested in this exhibition are invited to apply to Mr. E. Schofield, of 22-24, Great Portland Street, London, W.

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

THE last number of the transactions of the American Illuminating Engineering Society again contains a series of valuable papers.

H. E. IVES deals with the **measurement of brightness.** He gives the chief definitions and the formulæ connecting the illumination in foot-candles received by the surface, with its intrinsic brilliancy in candle-power per square inch ($b = \frac{m.E.}{\pi}$) An interesting example of varying degrees of brightness is provided by a photograph of a room illuminated by daylight, on which the surface brightness of various objects has been marked in. Various methods of measuring brightness are described; the discussion of this subject covers ground which is probably not well-known to many people in this country.

A. B. WILSON and F. J. BLASCHKE contribute a paper on the **Relation of the Illuminating Engineer to fixture design.** They show how the fundamental construction of fixtures has changed during recent years, much of the elaborate metal work which formerly used to obstruct the light being omitted. Now that such a variety of scientific glassware is available the problem of fixture design has been appreciably altered. One interesting item is an illustration of a series of fixtures and glassware for all the chief rooms in a house.

E. B. ROWE and H. H. MAGDSICK contribute a complete analysis of diffusing glassware, in which the proportion of direct and indirect lighting are discussed. A photograph and the polar curve of light distribution of each unit is shown and the amount of light distributed in the various zones worked out.

Among other contributions we note that of H. KIRSCHBERG and A. C. COTTON on **Railroad Illuminating Engineering,** and by H. SCOFIELD on **House Lighting.** The latter takes each room in the house in turn and shows a complete series of photographs of the hall, reception room, drawing room, dining room, bathroom, kitchen, &c. Semi-indirect lighting is largely used. The author discusses the best position of the lights in each case, the intensity of illumination required and the most suitable form of fitting.

Finally, special reference should be made to the Report of the Research Committee entitled **Harmful Radiations and the protection of the eyes therefrom.** The Committee have collected a unique series of references on the subject, which are arranged in alphabetical order. They say that it is difficult as yet to form definite opinions as to the effect of various kinds of radiations on the eye. But it is admitted that in some circumstances ultra-violet rays may be harmful, and it is possible that the infra-red rays are also of importance. The chief defects in previous researches have been that the exact nature of the radiation studied and its quantitative value are not precisely defined. The Committee suggest a series of researches which ought to be undertaken. Their report serves a useful purpose in clearing the way for future work.

There have also been several articles referring to the arrangements at the coming **Panama Exhibition.** The buildings are to be covered with jewel-like projections which are illuminated by searchlights, and there will be huge banners lighted from behind by flame arcs. Another interesting departure is the illumination of the façade of a building with white light, while concealed coloured

lamps will be added to give purple shadows. In some of the courts high pressure gas will be used, and in one case large gas flambeaux in the middle of a series of fountains will be used to indicate a symbol of the union of fire and water.

One other spectacular effect is rendered possible by the climatic peculiarities of San Francisco. Every evening banks of fog roll up to the gates of the exhibition and remain suspended in the air at a height of about 300 feet. It is proposed to illuminate this vapour with search-lights whose brilliancy will be gradually increased as the evening draws on.

An interesting paper by VOEGE on "**Objective Photometry**" is noticed elsewhere in this number.

GAS AND ELECTRIC LIGHTING.

There are few articles of importance dealing with electric lighting. The chief contribution is that of J. TEICHMULLER (*J.f.G.*, May 2nd) on the **development of the electric glow lamp.** The article traces the progress right up to the invention of the half-watt lamp. It is surely a sign of the times to find an article dealing exclusively with electric lighting appearing in a gas journal.

Much attention is given in the English gas journals to the Bills on Calorific Tests now before Parliament. An editorial in the *Journal of Gas Lighting* points out the need for occasional scrapping of posts, lanterns, &c., in connection with public lighting. Most people will agree that authorities are too often reluctant to make changes of this kind; the journal concludes by regretting the tendency towards expecting public lighting to be provided at an even lower rate instead of providing more light for the same money.

A recent article in the *Sanitary Record* points out the need for brighter illumination in the square adjacent to the Houses of Parliament and also in the London Parks. Many of the existing upright burners, it is suggested, might preferably be replaced by inverted ones.

A lecture by G. KEITH on the **Keith Silica Lamp** appears in several of the English journals. The lecturer describes various difficulties in the manufacture of these silica globes, which have now been substantially overcome. The globes have a distinct softening effect and reduce the brilliancy of the mantle considerably. Mr. Keith gives some interesting particulars about the proportion of gas and air necessary for complete combustion. With London gas a proportion of 4½ of air per one of gas can be obtained. With Blau gas the proportion might be 32 to 1, and in this case as much as 270 candle-power per cubic foot of gas are said to have been obtained.

WESTERMAIER (*American Gas Lighting Journal*, May 4th) contributes an article on the **lighting of streets with gas;** a number of characteristic American standards carrying clusters of white glass globes are shown. The author shows a photograph of a high pressure installation in Philadelphia. In this case also diffusing globes are employed.

In the German papers there are several articles of a technical character, notably the contribution by A. SCHEID of a new form of **distance lighter** (*J.f.G.*, April 25th), and a paper by WILHELM on **Street Lighting.** It is interesting to note that although street lighting by gas is so extensive in Berlin quite one-fifth of the streets so lighted use high-pressure lamps.

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Scrapping and Improvement in Public Lighting (*J. G. L.*, April 21st).
Keith, G. The Keith Silica Lamp (*G. W.*, May 2nd; *J. G. L.*, April 28th).
Scheid, A. Uber die Askania-Gasfernzündung (*J. f. G.*, April 25th).
Westermaier, V. Gas Street Lighting (*Am. Gaslight Jour.*, May 4th).
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CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. f. G.—*Journal für Gasbeleuchtung.*
J. G. L.—*Journal of Gaslighting.*
T. I. E. S.—*Transactions of the American Illuminating Engineering Society.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

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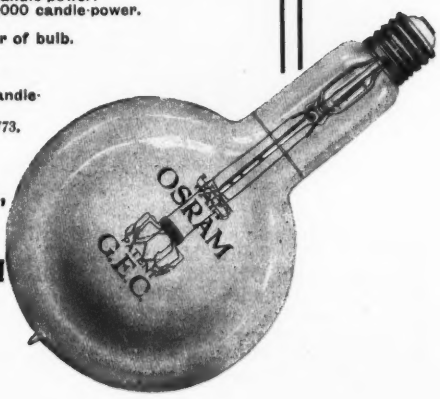
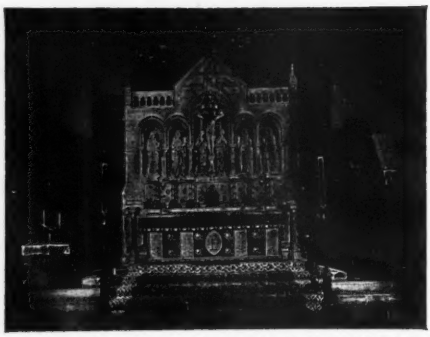


ILLUMINATION OF A CHURCH WITH CONCEALED LIGHTS.

In the Church of St. Anne's, Liverpool, concealed lighting with lamps in B.T.H. "Mirolux" lighting is employed.

Looking towards the altar the lamps are completely invisible, and the picture gives a good idea how the illuminated altar "stands out" from its surroundings.

We are informed by the **British Thomson Houston Company** that the arrangements are considered a great improvement on the lighting previously employed in this church.



A view of the Altar in St. Anne's Church, Edgehill, Liverpool, taken by artificial light.

A gas semi-indirect lighting installation. The Board Room at the chief offices of the South Metropolitan Gas Co

The picture shows a view of the Board Room of the South Metropolitan Gas Company in the Old Kent Road. According to a recent number of the *Co-partnership Journal*, from which this illustration is taken, the present Board Room dates back to 1881. On the wall will be seen a portrait of Sir Geo. Livesey.

The lighting of this room is interesting. It is derived from a central unit containing five metro. inverted gas burners each giving about 70 c.p. within a Holophane 20 in. hemisphere. Semi-indirect lighting with gas should give a distinctly fine effect with these large units.

TRADE TOPICS AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

CO-OPERATION WITH ILLUMINATING ENGINEERS.

The Gas Light and Coke Company's Offer.

We should like to draw attention to the advertisement of the Gas Light and Coke Company in the present number, offering to co-operate with members of the Illuminating Engineering Society in the planning of the lighting of buildings within their area of supply, and also in making experiments on illumination.

It is not often that we refer to advertisements in these columns, but in the present instance the attitude taken up by the Gas Light and Coke Company deserves such encouragement.

The practical effect of such co-operation is to bring those engaged in the lighting industry in contact with engineers desirous of carrying out principles set forth at meetings of the Illuminating Engineering Society. In this way the influence of the Society is extended, and the Company, by becoming familiarised with the practicability of these principles in daily life, will also be the gainer.

We should like to see this example followed by other lighting companies.

The practice has been found very beneficial in the United States, and to satisfy the consumer should be the aim of every company.

Since the above was written we have been informed that the South Metropolitan Gas Company is willing to extend the same facilities, so that the two leading gas companies of London are both adopting this enterprising policy.

THE LIGHTING OF PUBLIC BUILDINGS.

A recent number of *Holophane Illumination* contains a special series of articles on this subject, and several recent Holophane installations, such as the Kent County Offices at Maidstone, are described.

Kent County Offices, Maidstone.
Entrance Hall to Council Chamber, showing Holophane reflector bowls.

It is pointed out that the rooms in which committee and board meetings are held are often panelled in dark oak and require special lighting. In lofty and imposing rooms, luminous sources of a correspondingly impressive character are required.

MAZDA HOUSE NEWS.

The last issue of the *Mazda House News* again contains a variety of topical articles illustrating the British Thomson Houston installations. Of special interest at the present moment is the contribution dealing with Mazda lighting in railway trains, where some views of carriages on the Chicago Rock Island Railway of America, lighted by Mazda Lamps and Holophane and Veluria reflectors, are shown. On this railway the value of proper shading of the lights is evidently appreciated.

Another article on "Light and Labour" points out the economic value of good lighting. It includes two illustrations showing the contrast between good and bad lighting in a textile mill.

SIEMENS CONTRACTS.

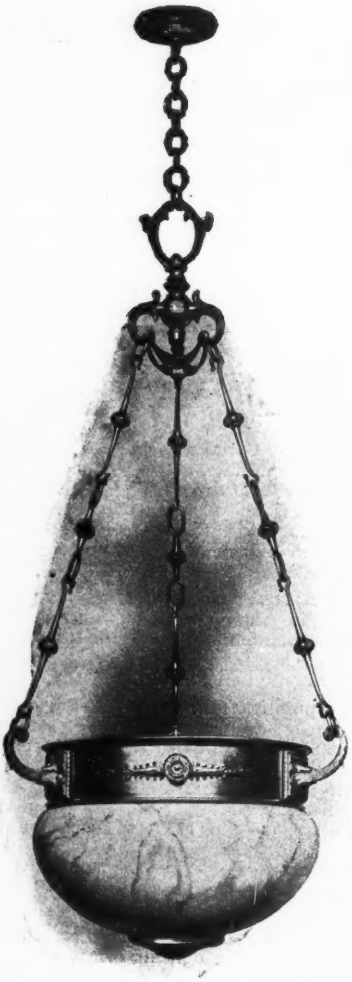
Messrs. Siemens Bros. Dynamo Works, Ltd. (Tyssen Street, Dalston, London, N.E.), inform us that they have received from the Controller of the Stores of the General Post Office an acceptance of their tender for the supply of Wotan drawn wire lamps. A tender has also been accepted for lamps of this same variety for the Nottingham Corporation Electricity Department; this contract also applies to carbon lamps.

EDISON AND SWAN SHOW ROOMS.

Our attention has been drawn to the fact that the **Edison and Swan United Electric Light Company, Limited,** have opened a West End Show Room at 71, Victoria Street, Westminster, S.W. The showroom will be devoted to all Ediswan Electrical accessories such as lamps, fancy fittings, heating apparatus and glassware, &c.

Last month we referred to a visit of the Association of Engineers in Charge to the Ediswan Works. We notice that a visit of the Members of the University of the Birmingham Engineering Society took place on May 1st.

We also observe that this Company is now listing a convertible table bracket fan. This can be run at three distinct speeds, is noiseless and sparkless, and is so designed that no live parts are accessible.



Semi-indirect fitting with marble bowl (Messrs. Falk, Stadelmann & Co., Ltd.). Similar fittings are also prepared with the lights concealed in marble vases.

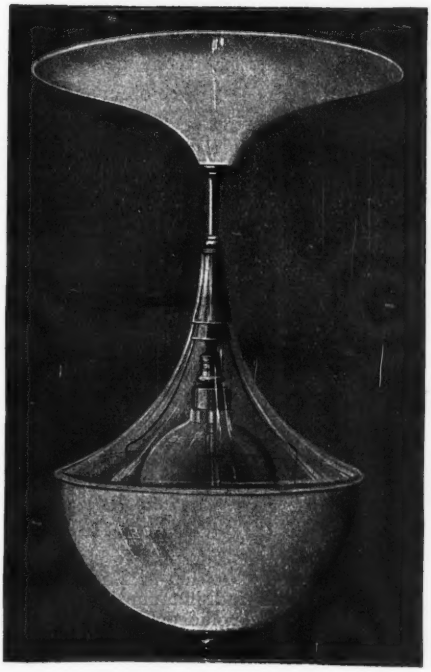
INDEX, June, 1914.

		PAGE
Congresses, Forthcoming		322
Editorial	L. GASTER	277
Illuminating Engineering and The Architect		294
Illuminating Engineering, Short Notes on		317
Illuminating Engineering Society— (Founded in London, 1909.)		
Lighting of Railway Carriages and other Public Vehicles	(J. Darch; W. Perren Maycock)	301
Annual General Meeting		307
Report of Council		309
New Members		316
Night Work and the Spoilage of Materials		294
Objective Photometry	W. VOEGE	295
Railway Carriages and other Public Vehicles, The Lighting of	(J. DARCH; W. PERREN MAYCOCK)	301
Reviews of Books		321
Review of the Technical Press		323
Trade Topics		226
Street Lighting in Europe and America	C. F. LACOMBE	281
Street Lighting, Suggestions for the Advancement of in the United States	C. F. LACOMBE	293

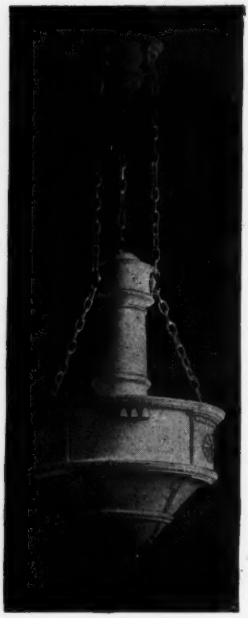
SEMI-INDIRECT LIGHTING.

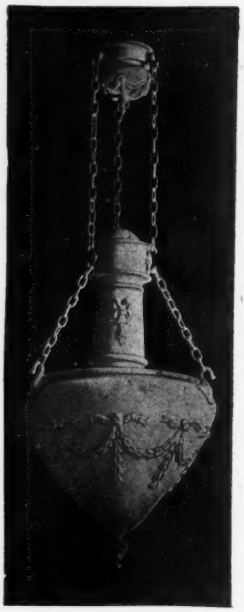
Messrs. Falk, Stadelmann & Co., Ltd., have issued a catalogue, from which the adjacent illustrations are taken, devoted entirely to indirect and semi-indirect fittings. The fitting beside this note is suitable for commercial work, especially in rooms where too much reliance must not be placed on the reflecting power of the ceiling. It is shown with a single lamp, but is also adapted to clusters. The complete enclosure of the lamp is doubtless a help in cleaning, always an important point in indirect lighting.

The picture on the opposite page is characteristic of the many designs in marble, and there would seem to be a future for decorative semi-indirect fittings using this material.



B.T.H. INDIRECT UNITS.





This illustration shows some characteristic B.T.H. Indirect Units. Now that the Half-watt lamp is coming into general use these fixtures are expected to be widely adopted. It will be observed that the white exterior surface of such fittings does much to remove the appearance of darkness when the fitting is seen silhouetted against the bright ceiling, which is sometimes complained of as a drawback to indirect lighting.

OPALUX GLASSWARE.

We have received from the **Opalux Company** (71, W. 23rd Street, New York) a copy of their latest catalogue of glassware. This is printed throughout in brown ink on matt paper, and is arranged on a decidedly novel plan. There is an introduction summarising the chief aims to be followed in modern lighting appliances. Each section then commences with an artistic landscape illustration. A photograph of every unit is accompanied by the corresponding polar curve and full illumination data, and the book is concluded by a series of general notes on illuminating engineering.

We think that the arrangement of this catalogue would interest many manufacturers in this country, and some of its features might with advantage be more widely adopted.

ALUMINIUM "STRIPLITE."

The General Electric Company, Limited (67, Queen Victoria Street, E.C.), draw our attention to a reduction in price in the aluminium striplite reflectors, which are now supplied at 4s. per unit length (reflector only). It is well-known that this type of reflector is used with tubular lamps and is intended for concentrating the light in one direction, as is frequently desired in shop window lighting, &c.

7

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
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EDITORIAL.

The Nomenclature and Definitions of Illuminating Engineering.

In this number we are reproducing Mr. Trotter's paper on the above subject, together with the complete discussion and his reply. At the same time we are reprinting the Report of the Committee of the American Illuminating Engineering Society, presented at the Baltimore Convention in 1911, on which Mr. Trotter's paper comments somewhat fully.

We feel sure that all will recognise the skill with which Mr. Trotter has dealt with this somewhat intricate and technical subject. The very considerable amount of attention which the paper has received in the technical Press is a tribute to his art in making attractive any subject in which he himself is interested.

The time was certainly ripe for a paper on this subject. As a result of the pioneering work of the last few years many terms which were previously only understood by the enlightened few are now coming into general use. Such expressions as " the foot-candle " are now becoming common property, and we believe that in the course of the next few years there will be many others which will become equally familiar. It is therefore essential that the Society should give a lead to the lighting industry by expressing the meaning of these terms clearly and ensuring that they are rightly presented and used.

Mr. Trotter's paper is valuable in drawing attention to the correct usage of many expressions, on which there is a substantial agreement. There is sometimes a tendency in such discussions to accentuate points of difference. We would like to point out that there is already a great deal of common ground. In this respect considerable progress has been made during the last few years. Now the time has come to collect existing data and settle the points which are still debatable. While, naturally, the terms and definitions which have come into use in various countries do differ somewhat, there is a good prospect that a compromise will eventually be reached that will satisfy all.

The Committee of the American Illuminating Engineering Society deserve full credit for their attempt to frame a model series of definitions. These will serve as a basis for discussion. But there are many respects in which the conditions in this country differ from those in the United States, and it is only natural that there should be hesitation in accepting these proposals *in toto*. Over here new ideas are welcomed more cautiously, but, once accepted, are held more tenaciously. A new system cannot be suddenly imposed on the entire lighting industry from headquarters. It has to win the approval, gradually, of all the individual concerns interested. At this stage it would clearly be a bad policy to adopt any sudden departure in phraseology, involving the substitution of unfamiliar and less readily comprehensible terms for those which have gradually won their way into favour. In order to encourage those on the fringe of the illuminating engineering movement to take a part in its work, our nomenclature should be as simple as possible.

Again, there are special classes of work in which the use of certain terms has become standardised, and methods are used which, although not rigidly correct from a scientific standpoint, are nevertheless very convenient. A case in point is furnished by researches on sky brightness and its influence on the natural lighting of schools. In much Continental work the so-called " secondary " method of defining brightness has been used, and has certain distinct advantages for this work, notwithstanding that it is possibly open to objection on purely scientific grounds.

We fully recognise the force of the contentions of Dr. Bunte, Prof. Blondel, and others that the nomenclature and definitions of a science should be framed to meet the needs of scientific men, and not to suit the so-called " practical man," whose ideas are often influenced by transient conditions and obsolescent practices. We agree that the fundamental terms used in illuminating engineering should, when possible, be defined in a permanently satisfactory, scientific manner.

But yet we must recognise that Illuminating Engineering touches many other professions, and is not quite in the same position as other sciences. Illumination is everybody's business. Its terminology, therefore, should not be unduly complicated, but readily intelligible to the man in the street.

We hope that a *via media* may be found. Mr. Trotter's paper has been the means of eliciting some very able statements of both points of view, and the discussion will doubtless prove a useful introduction to the deliberations of the National Illumination Commission, which in turn will bring the matter before the International Commission on Illumination for final consideration.

The Natural Lighting of Schools.

On pp. 359–368 we reproduce the Interim Report on the above subject issued by the Joint Committee on School Lighting, appointed in 1911. The Report is a record of a considerable amount of hard work. The Sub-Committee responsible, besides meeting at frequent intervals, have visited schools in and out of London and made a series of photometric tests. Not the least important part of the work has been the collection of existing data, and the summarising of Continental Research. Throughout the Committee has been extremely fortunate in having at its disposal the experience and knowledge of its Chairman, Dr. James Kerr.

The difficulties attending this work were increased by the fact that wide differences of opinion were found to exist on fundamental points. The paper read before the Society by Mr. Waldram, one of the members of the Committee, last December, led to a discussion which was most useful in clearing the ground ; and the series of inquiries circulated among authorities in various countries was equally valuable in showing the gaps in our knowledge and the present state of expert opinion.

In the circumstances the Report is necessarily an interim one. It is pointed out that accommodation of vision plays a great part in daylight phenomena, so that it is hardly possible to specify an absolute standard of illumination, as in the case of artificial light. Nevertheless there is some ground for suggesting that the minimum illumination for reading should in general not be less than 2 foot-candles, as specified for artificial light.

The daylight conditions in schoolrooms can only be specified *relatively*. The Committee has done good work by showing that the customary recommendations as regards the ratio between internal and external illumination, the " sill-ratio " and the " 50 square degrees " of Cohn, all lead to substantially the same conditions ; and that the existing rules of the Board of Education will in general secure that these scientifically determined conditions are fulfilled. The series of practical recommendations represent the essence of expert opinion, and will, we feel sure, receive the support and endorsement of all school lighting authorities.

Not the least important part of the Report is the final series of suggested researches. Many of these are beyond the unaided resources of the Committee. We trust, now that the importance of the work to be done has been demonstrated, adequate support will be forthcoming from the Educational Authorities for the prosecution of some of these researches. There are two lines of investigation that seem to us eminently practicable and that we should particularly like to see encouraged.

The first of these is the carrying out, at various stations, of a systematic series of tests of daylight illumination throughout the year.

The second research on which we lay special stress is the establishment of machinery for obtaining and recording full information, including photometric tests, of new schools being erected in different parts of the country. Much is to be learned by the study of new departures in design, and we think it would be greatly to the benefit of the Educational Authorities to arrange for the collection of information on this subject.

The Photo-Electric Cell in Photometry.

For some time experiments with various forms of " physical " photometers have been proceeding. Special applications have been found for photography, the thermopile, and the selenium cell ; but the utility of all such appliances in photometry has hitherto been restricted by various difficulties—for example, the differences in the way such apparatus responds to light of various colours, as compared with the human eye.

Still, it has always seemed possible that such methods might be used for purely *relative* work, *i.e.*, in studying daylight or in the comparison of lamps of the same class. Our last issue contained an article by W. Voege (pp. 295-300) describing some experiences with the alkali metal cell, which seems to have several distinct advantages over those using selenium. For example, the reading obtained is strictly proportional to the illumination over a very wide range, and the cell is practically free from inertia.

For relative work, therefore, it would seem to have distinct possibilities, but the small current to be measured (10^{-9} amperes) makes it essentially a method for the laboratory. We should be inclined to think that one of the chief applications of these methods would be in refinements of laboratory work, where one is anxious to detect very small changes in candle-power. It so frequently happens in such cases that the eye is deceived ; it is therefore necessary to repeat observations with different observers and to go through a good deal of tedious confirmatory work before one can be sure that the apparent result is a correct one. Now if the reading with the photometer were checked by a purely physical method, the danger of personal error would be eliminated. It is possible, too, that by the aid of a photo-electric cell small changes might be detected which would otherwise pass unnoticed, and that this method might sometimes prove more sensitive than the human eye.

We should imagine that a highly sensitive and trustworthy physical method would be of considerable value in studying variations of light standards. Here minute changes in candle-power, occasioned by small differences in adjustment or by fluctuations in atmospheric conditions, are often of considerable scientific importance, and yet are by no means easy to detect. Hitherto most of these effects have been verified by going over the same ground again and again, and checking the results of different observers. Now it is possible, since we are here concerned solely with *relative* results, that a trustworthy physical photometer would be a valuable weapon and might enable a conclusion on many of these debatable points to be reached much more quickly.

Another possible application of the method would be in connection with polar curves of light distribution. This is also a case where only relative results are required. In general the nature of the radiation from a source in space is practically the same in all directions. In laboratories where the polar curves of light distribution from a large number of sources, or from many different types of reflectors have to be taken, a great deal of time might be saved by a convenient photo-electric device, such as this new cell promises to be.

We shall await, with considerable interest, further experiments on the alkali cell in photometry.

L. GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

[On pages 339–345 in this issue will be found the paper read at the last meeting of the Illuminating Engineering Society by Mr. A. P. Trotter on "The Nomenclature and Definition of Photometric Magnitudes and Units."

This paper deals mainly with the proposals on this subject put forward in the Report of the American Committee of the American Illuminating Engineering Society, which was presented at the Annual Convention of 1911. At the request of several members of the Illuminating Engineering Society in this country we are reprinting this Report *in extenso*, so that it may be read in conjunction with Mr. Trotter's paper. ED.]

REPORT OF THE COMMITTEE OF THE AMERICAN ILLUMINATING ENGINEERING SOCIETY ON NOMENCLATURE AND STANDARDS.[1]

PROPOSED DEFINITIONS.

Your committee has held many meetings during the past year for the consideration of definitions of photometric quantities and begs to submit the following list tentatively adopted :

Luminous flux is radiant power evaluated according to its capacity to produce the sensation of light.

The stimulus coefficient K_λ for radiation of a particular wave-length is the ratio of the luminous flux to the radiant power producing it.

The mean value of the stimulus coefficient, K_m, over any range of wave-lengths, or for the whole visible spectrum of any source, is the ratio of the total luminous flux (in lumens) to the total radiant power (in ergs per second, but more commonly in watts).

The luminous intensity of a point source of light is the solid angular density of the luminous flux emitted by the source in the direction considered ; or it is the flux per unit solid angle from that source.

[1] Transactions of the Illuminating Engineering Society (U.S.A.), December, 1912.

Defining equation :

Let I be the intensity, F the flux and ω the solid angle.

Then $$I = \frac{dF}{d\omega}, \text{ or, if the intensity is uniform,}$$

$$I = \frac{F}{\omega},$$

Illumination, on a surface, is the luminous flux-density over that surface, or the flux per unit of intercepting area.

Defining equation :

Let E be the illumination and S the area of the intercepting surface.

Then $$E = \frac{dF}{dS}, \text{ or, when uniform,}$$

$$E = \frac{F}{S},$$

Candle,—the unit of luminous intensity maintained by the National Laboratories of France, Great Britain, and the United States.[2]

Candle-power,—luminous intensity expressed in candles.

Lumen,—the unit of luminous flux, equal to the flux emitted in a unit solid angle (steradian) by a point source of one candle-power.[3]

Lux.—a unit of illumination equal to one lumen per square meter. The C.G.S. unit of illumination is one lumen per square centimeter. For this unit Blondel has proposed the name " Phot." One millilumen per square centimeter (milliphot) is a practical derivative of the C.G.S. system. One foot-candle is one lumen per square foot and is equal to 1·0764 milliphots.

Exposure,—the product of an illumination by the time. Blondel has proposed the name " phot-second " for the unit of exposure in the C.G.S. system.

Brightness, b, of an element of a luminous surface from a given position, is the luminous intensity per unit area of the surface projected on a plane perpendicular to the line of sight, and including only a surface of dimensions negligibly small in comparison with the distance to the observer. It is measured in candles per square centimeter of the projected area.

Defining equation :

Let θ be the angle between the normal to the surface and the line of sight.

Then $$b = \frac{dI}{dS \cos\theta}$$

Normal brightness, b_0, of an element of a surface (sometimes called *specific luminous intensity*) is the ratio of the luminous intensity of the element taken normally to the surface of the element, and is expressed in candles per square centimeter.[4]

Defining equation :

$$b_0 = \frac{dI}{dS}, \text{ or, when uniform,}$$

$$b_0 = \frac{I.}{S},$$

[2] This unit, which is used also by many other countries, is frequently referred to as the international candle.

[3] A uniform source of one candle emits 4π lumens.

[4] In practice, the brightness b of a luminous surface or element thereof is observed, and not the normal brightness b_0. For surfaces for which the cosine law of emission holds, the quantities b and b_0 are equal.

Specific luminous radiation,—the luminous flux-density emitted by a surface, or the flux emitted per unit of emissive area. It is expressed in lumens per square centimeter.

Defining equation:

Let E′ be the specific luminous radiation.

Then, for surfaces obeying the cosine law of emission,

$$E' = \pi b_0.$$

Coefficient of reflection,—the ratio of the total luminous flux reflected by a surface to the total luminous flux incident upon it. It is a simple numeric. The reflection from a surface may be regular, diffuse or mixed. In perfect regular reflection, all of the flux is reflected from the surface at an angle of reflection equal to the angle of incidence. In perfect diffuse reflection the flux is reflected from the surface in all directions in accordance with Lambert's cosine law. In most practical cases there is a superposition of regular and diffuse reflection.

Coefficient of regular reflection is the ratio of the luminous flux reflected regularly to the total incident flux.

Coefficient of diffuse reflection is the ratio of the luminous flux reflected diffusely to the total incident flux.

Defining equation:

Let m be the coefficient of reflection (regular or diffuse).

Then, for any given portion of the surface,

$$m = \frac{E'}{E}$$

Primary luminous standard,—a recognised standard luminous source reproducible from specifications.

Representative luminous standard,—a standard of luminous intensity adopted as the authoritative custodian of the accepted value of the unit.

Reference standard,—a standard calibrated in terms of the unit from either a primary or representative standard and used for the calibration of working standards.[5]

Working standard,—any standardised luminous source for daily use in photometry.

Comparison lamp,—a lamp of constant but not necessarily known candle-power against which a working standard and test lamps are successively compared in a photometer.

Test lamp, in a photometer,—a lamp to be tested.

Performance curve,—a curve representing the behaviour of a lamp in any particular (candle-power, consumption, etc.) at different periods during its life.

Characteristic curve,—a curve expressing a relation between two variable properties of a luminous source, as candle-power and volts, candle-power and rate of fuel consumption,[6] etc.

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[5] It is desirable that the representative luminous standard should be a primary luminous standard as above defined, but if the precision with which the primary standard can be reproduced is insufficient, the representative standard may have to be constituted in some other manner as, for example, by a group of seasoned incandescent electric lamps in which the mean value of the group, originally derived from some primary standard, is assumed to remain constant, and is used to maintain the value of the unit. Thus, the Hefner lamp is in Germany both the primary and the representative standard, whereas in America it is a primary standard, but not the representative standard. In the United States, the representative standard is a group of seasoned incandescent lamps at the Bureau of Standards in Washington. This is the most authoritative source for the calibration of reference standards in the United States.

[6] Curves expressing the behaviour with respect to time of life are here excluded, being considered as performance curves.

Mean horizontal candle-power of a lamp,—the average candle-power in the horizontal plane passing through the luminous centre of the lamp.

It is here assumed that the lamp (or other light source) is mounted in the usual manner, or, as in the case of an incandescent lamp, with its axis of symmetry vertical.

Mean spherical candle-power of a lamp,—the average candle-power of a lamp in all directions in space. It is equal to the total luminous flux of the lamp in lumens divided by 4π.

Mean hemispherical candle-power of a lamp (upper or lower),—the average candle-power of a lamp in the hemisphere considered. It is equal to the total luminous flux emitted by the lamp in that hemisphere divided by 2π.

Mean zonal candle-power of a lamp,—the average candle-power of a lamp over the given zone. It is equal to the total luminous flux emitted by the lamp in that zone divided by the solid angle of the zone.

Spherical reduction factor of a lamp,—the ratio of the mean spherical to the mean horizontal candle-power of the lamp.[7]

TABLE I.

Photometric magnitude.	Name of unit.	Symbols and equations of definitions.
1. Luminous flux	Lumen	F. Ψ
2. Luminous intensity	Candle	$I = \frac{dF}{d\omega}$ $\Gamma = \frac{d\Psi}{d\omega}$
3. Illumination	Phot., foot-candle, lux	$E = \frac{dF}{dS} = \frac{I}{r^2} \cos\theta . \beta$
4. Exposure	Phot-second	Et
5. Brightness	Apparent candles per sq. cm. Apparent candles per sq. in.	$b = \frac{dI}{dS \cos\theta}$
6. Normal brightness	Candles per sq. cm. Candles per sq. in.	$b_0 = \frac{dI}{dS}$
7. Specific luminous radiation	Lumens per sq. cm. Lumens per sq. in.	$E' = \pi b_0$
8. Coefficient of reflection	—	$m = \frac{E'}{E}$

Symbols.

In view of the fact that the symbols heretofore proposed by this committee conflict in some cases with symbols adopted for electric units by the International Electrotechnical Commission, it is proposed that where the possibility of any confusion exists in the use of electrical and photometrical symbols, an alternative system of symbols for photometrical quantities should be employed. These should be derived exclusively from the Greek alphabet, for instance :

Luminous intesity	Γ
Luminous flux	Ψ
Illumination	B

[7] In the case of a uniform point-source, this factor would be unity, and for a straight cylindrical filament obeying the cosine law it would be $\pi/4$.

THE NOMENCLATURE AND DEFINITION OF PHOTOMETRIC MAGNITUDES AND UNITS.

By A. P. TROTTER.

Paper presented at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.C.), at 8 p.m., on Thursday, May 21st, 1914.

At the Baltimore Convention of the Illuminating Engineering Society of New York, on October 24th, 1910, a report was submitted by Prof. A. Blondel, Dr. A. E. Kennelly, Prof. E. L. Nichols, Dr. E. B. Rosa, and Prof. C. H. Sharp, members of a sub-committee on photometric units. After holding many meetings another report was presented in December, 1912, submitting certain definitions to be tentatively adopted. The object of the present paper is to examine these definitions and to elicit some discussion on them.

There can be no question about the scientific accuracy or logical exactness of a report coming from authorities so well known by name and reputation to all those who have made a study of the science and industrial applications of photometry, but questions may be raised about the terminology and the choice of units and the general scheme of the proposition.

The measurements of modern physical science are securely established on three fundamental units of length, mass, and time. Everett* pointed out that "this particular selection is a matter of convenience rather than necessity; for any three independent units are theoretically sufficient. For example, we might employ as fundamental units a definite mass, a definite amount of energy, a definite density." Everett observed that it is desirable that the fundamental units be so chosen that the definition of the various derived units shall be easy and their dimensions simple. To this may be added that it is an advantage that a well-known or frequently used magnitude should be the fundamental rather than one which only appears after theoretical considerations. The synthetic method. as in geometry, the method of induction which is generally used by the physicist and engineer, starts from the simple and proceeds to the complex. The analytic method of attacking and reducing the complex is instinctive to the mathematician, and the analogous deductive processes are characteristic of the philosopher who works from the general to the particular. The synthetic method lays the foundation of the centimetre, the gramme, and the second, and is prepared to express any physical quantity in terms of these units. The philosopher turning his back on such crudities tells us that it is doubtful if space exists and assures us that time is an illusion. It may be philosophical to take the most abstract concepts first and to attempt to define particulars in terms of the general, but for most of us it is better to anchor ourselves to the most simple units that we can find, and then, letting out the cable of inductive reasoning, float over wider and wider ranges of ideas, always co-ordinating them to our bearings.

The first and fundamental quantity chosen by this Committee is as follows:

"*Luminous flux* is radiant power evaluated according to its capacity to produce the sensation of light."

The natural and obvious quantity would seem, to most of us, to be "candle-power." This comes as the seventh quantity, and is defined:—

"*Candle-power* — luminous intensity expressed in candles."

This sends us to "luminous intensity," the fourth in the report, and is thus defined:—

"*The luminous intensity* of a point source of light is the solid angular density of the luminous flux emitted by the source in the direction considered; or it is the flux per unit solid angle from that source."

None of these are simple, and the last appears to be a rather complex quantity,

* Units and Physical Constants.

especially to anyone who knows little or nothing about solid angles or flux, but who *thinks* that he knows what is meant by "candle-power." Twenty-four years ago* I wrote, "Light being an expenditure of energy, candle-power is an accurate term, since it is the measure of the rate of expenditure of energy." To this it may be answered, "Why drag in energy?" Light is defined in most dictionaries and encyclopædias subjectively, as in the first definition of the U.S. Report of 1910. "Light is the stimulus produced by radiation, which excites vision." But light may also be defined objectively. The sensation of light is a subjective affair to which magnitudes and units cannot be applied. It is one of the elementary principles of photometry that the only ratio that can be visually determined is that of equality.

The sensation of light is the result of the stimulation of the optic nerve through the retina. This stimulation takes place when the frequency of the undulations of radiation is between about 4×10^{14} and 8×10^{14}, about one octave. Below this is infra-red radiation, above is ultra-violet. These infra-red and ultra-violet radiations, and mechanical pressure, will affect a photographic plate. Pressure and electric current also produce the sensation of light. Whether the range of the spectrum visible by man is different from that visible to other animals does not seem to have been investigated. For those who are not engaged in extending the borders of physics, the undulatory hypothesis of light still remains plausible and useful. Dr. Schuster has said that in the expressions we adopt to describe physical phenomena we necessarily hover between two extremes. We either have to choose a word which implies more than we can prove, or we have to use vague and general terms which hide the essential point instead of bringing it out; and he has said elsewhere that it is not necessary to wait until we can define the displacements which constitute the waves before we attempt an objective definition of light. But this is not the place to discuss whether Kelvin and others were right or wrong in holding that radiant heat and radiant light are identical. Kelvin's statement—"If you see it, it is light"—will suffice for our present purpose.

The term "candle-power" is used in two senses. In one sense it connotes an abstract idea like area or pressure, and in the other it is a vector quantity and denotes a definite physical magnitude. In the former sense it is synonymous with "luminous intensity," but has taken such a hold on the English language that it is difficult to get rid of it. In the latter sense, the name of the physical unit of luminous intensity, the "candle," may often be substituted for "candle-power." Prof. A. Blondel shudders not only at our expression "candle-power," but at our use of "candle" as a physical unit. "It is as unscientific," he writes, "to call the unit of intensity 'an international candle' as it would be to call the unit of electromotive force an 'international battery,' or the unit of heat an 'international stove.'"

This intensity, or strength, or power, or rate of emission of light is a simple vector quantity, although in some cases, such as in a thick mist, or in the upper part of a lighted candle, the direction is not possible to define. Assuming a sensibly transparent homogeneous medium, and a point source, the direction is radial to the source and the unit of intensity is that of one "candle." This, on account of its simplicity and its primary character, has strong claims to be regarded as the fundamental unit in photometry.

The expression "intensity" deserves some consideration. In the vocabulary of the Nomenclature Sub-Committee of the British Electrotechnical Committee it is observed that "there is an increasing disposition to restrict the use of the word 'intensity' in English physical science to a ratio, the denominator being an area. The older meaning was synonymous with strength." According to the admirable logic of French thought, an electric current is a phenomenon. An ampere is not the unit of current, but it is a physical quantity and is the unit of the intensity of the current. In English we feel no necessity for the introduction of the word intensity, and we express the

* Proceedings Institution of Civil Engineers, Vol. CX., p. 69.

magnitude of an electric current in amperes.

These different usages, however, do not seem to afford a reason for defining luminous intensity or candle-power as the solid angular density of the luminous flux emitted by the source. I have shown in my book on "Illumination" that rainfall may be measured as a volume, or as an area of vertical section (as is usual in gauging the flow of a river), or simply as a height. The first way employs three dimensions of water and two of land; the second suppresses one of each of these dimensions and leaves two of water and one of land; the third again suppresses one of each of the dimensions, and leaves one of water and a mathematical point of land. There is no water left. True, but this is no objection, for the magnitude is not one of a quantity of water but of the intensity of rainfall. Another analogy into which the concept of a solid angle may be introduced, if we please, is afforded by a spherical vessel containing gas under pressure. Owing to the kinetic energy of the molecules a pressure is exerted on the sides of the vessel. A solid angle having its apex at the centre of the vessel, and subtended by one square inch of the internal surface of the vessel, may be considered, and it may be found that a pressure of 140 pounds is exerted on this square inch. This is a convenient mode of expressing the pressure. But the intensity of this pressure is exerted at every point on the spherical surface, measured, it is true, in pounds per square inch, but not needing a square inch, or indeed a surface of any conceivable magnitude, for it may simply be expressed as a pressure of 10 atmospheres or 300 inches of mercury. Similarly, the idea of a solid angle may be dismissed in considering the luminous intensity of a source of light; the idea of flux density imports redundant dimensions. It may be said that here is a false analogy. Our practical unit is the pound, not the pound per square inch. True, but Everett furnishes the answer—it is a question of convenience, and the fundamental units should be easy of definition and of simple dimensions. The relation between a lumen and a candle-power is a mere matter of arithmetic.

The choice of luminous intensity or candle-power for the fundamental magnitude defers the concept of flux and solid angle until these are wanted.

The magnitude of second importance, but coming fifth in the list of the Committee, is "illumination." This is defined:—

"*Illumination* on a surface is the luminous flux-density over that surface or the flux per unit of intercepting area." Seeing the great industrial importance of describing, specifying, calculating, and measuring illumination, and seeing, too, that the units foot-candle and *metre-kerze* are well established, it is unfortunate that a definition of this quantity should be proposed which is so difficult for a layman to grasp.

To understand what is meant by illumination, let us not generalise about the concept, but go straight to the units by which it is always measured. Illumination consists of two factors, candle-power and distance. The British and U.S. unit is the foot-candle. It is the illumination received from the source of one candle-power falling perpendicularly on a surface at a distance of one foot from the source.

In this definition it is desirable to use the words "received from" and not "produced by" in order to make a clear distinction between illumination and brightness.

The U.S. definition — "*Illumination*, on a surface, is the luminous flux-density over that surface, or flux per unit of intercepting area"—and the definition of the unit, "*Lux*, a unit of illumination equal to one lumen per square meter," sends us wandering over the definition of flux density and its unit—"Lumen—the unit of luminous flux, equal to the flux emitted in a unit solid angle (steradian) by a point source of one candle-power." To this is added a footnote, "A uniform source of one candle emits 4π lumens." The definitions, which are quite unintelligible to a layman who has not given some consideration to the concepts of flux and solid angle (the term "steradian" is practically unknown in Great Britain), contain dimensions which are not logically necessary and which give rise to the complication. The lumen, origin-

ally introduced by Prof. Blondel, is a very important unit, but it should be a derived one, just as a unit of volume is derived from the unit of length. In dealing with light, as with magnetism, we cannot avoid 4π and the solid angle. One course is to embody 4π in a unit, the other is to wait until we meet it, and a good deal can be done in photometry and illumination before this necessity arises.

The introduction of a solid angle and an intercepting area is as tautological as speaking of a horse-power-hour per hour. Assuming that a mental picture of the unit solid angle is formed with a candle at the apex, these definitions further demand the conception of an area of one square foot equidistant at all points from the apex, forming part of a sphere; otherwise the illumination would not be uniform. The simple foot-candle definition demands only the mental picture of a candle and a small surface facing it, which, if fairly small, say the size of a penny, may be flat, for the illumination at the edge of such a disc received from a theoretical point source will be 0·996 of the illumination at the centre, that is to say, practically uniform. This conception of the unit of illumination makes for economy of thought.

It is highly satisfactory that the "candle," a definite physical quantity measurable to a fraction of one per cent., has been agreed upon by the authorities in the United States, France, and Great Britain, but so long as the Hefner unit is also regarded as a unit of intensity of illumination it is not wise to use the terms lumen and lux without qualifying them as candle-lumen, Hefner-lux, &c.

The meter-candle will naturally be used in countries where the metric system is in common use, but since a metre is so nearly equal to the square root of 10 feet, one foot-candle is equivalent to 10·76 metre-candles, or for most practical purposes to 10 metre-candles.

The effort to think of a lumen per square meter of the surface of a sphere of one meter radius is reduced by the proposal of a unit to be named "Phot" where the illumination is one lumen per square centimetre. This would be very high illumination and the "millphot," or one-thousandth of a lumen per square centimetre, is of a practical magnitude, 1·076 milliphots being equal to one foot-candle. It does not seem likely that this will "catch on" in this country.

The name "*exposure*" is suggested in the U.S. report for the product of illumination by time. Prof. Blondel has proposed the name "phot-second" for the unit. The "bougie-metre-second" was adopted at the International Photographic Congress at Brussels in 1891, but little has been heard of it. Useful as it might be for photography, it seems a pity to give it a name with so narrow an implication. It might be called "quantity of illumination." Prof. Blondel recommended, some years ago, the "lumen-hour" as a unit on which commercial contracts for lighting should be based.

The next term on the list is *Brightness*. This word is used in two senses, emissive brightness of a source of light, and reflective brightness of an illuminated surface. The U.S. definitions relate apparently only to the former. "*Brightness of an element of a luminous surface from a given position* is the luminous intensity per unit area of the surface projected on a plane perpendicular to the line of sight, and including only a surface of dimensions negligibly small in comparison with the distance of the observer. It is measured in candles per square centimetre of the projected area." "*Normal brightness of an element of a surface* (sometimes called *specific luminous intensity*) is the ratio of the luminous intensity of the element taken normally to the surface of the element, and is expressed in candles per square centimetre." Perhaps this refers to secondary brightness of a diffusive reflector. If so, there seems to be no need for restricting it to the normal direction. Such reflectors are very useful in other directions.

The pith of these two definitions is that brightness is to be expressed in candles per square centimetre. The rest, and the equations which are given in the report, explain how the definitions are applied. Emissive brightness, when not expressed in candles per square inch, has hitherto been given in candles per square millimetre; the brightness of the

crater of a carbon arc is about 160, and of a candle flame about 0·39 candle per sq. mm. This quantity is *éclat intrinsèque* in French, or *primäre Helligkeit* (P.H.) or merely *Helligkeit* in German. We have a similar word, "brilliance," but, like the French word *clarté*, it is not used as a scientific term. We have another word, "luminosity," but that has been used by Abney and others in connection with the spectrum.

Brightness has another and very important meaning for which the term "surface brightness" or "secondary brightness" is sometimes used; the German equivalent is "*flächenhelle*," or "*sekundäre Helligkeit* (S.H.). A perfectly white unpolished surface of an area of π square feet receiving an illumination of one foot-candle becomes a secondary source of illumination equivalent to one candle normally, and has a hemispherical candle-power of one half-candle, but this reflective brightness is generally expressed and measured in a different way.

It is of great practical importance that "surface brightness" should be recognised as a definite and accurately measurable physical magnitude, whatever name is given to it. It is a compound quantity consisting of two factors, illumination and the coefficient of diffused reflection. Several practical instruments with which industrial photometry is carried out depend entirely on the measurement of brightness. Sometimes the object is not to measure brightness, but to measure illumination. For this purpose a piece of white card or unpolished celluloid is used. When this receives an illumination of one foot-candle and is observed through the instrument, the brightness is found to be equal to the brightness of a screen contained in the instrument when one foot-candle is indicated on the scale. The instrument being calibrated by experiment, measurements of illumination may be made with it.

But this unit reading does not correspond with the true unit brightness. The card or celluloid reflects only about 80 per cent. of the light incident on it, in other words, its coefficient of diffused reflection is about 0·8 or its albedo is 0·8. If this is measured, the coefficient of diffused reflection of other surfaces receiving the same illumination may be directly compared. A knowledge of this coefficient for different coloured paint, distemper, or wall paper is of great practical importance. This coefficient is the next term defined.

Coefficient of Reflection. "The ratio of the total luminous flux reflected by a surface to the total luminous flux incident upon it. It is a simple numeric. The reflection from a surface may be regular, diffused or mixed. In perfect regular reflection all of the flux is reflected from the surface at an angle of reflection equal to the angle of incidence. In perfect diffused reflection the flux is reflected from the surface in all directions in accordance with Lambert's cosine law. In most practical cases there is a supposition of regular and diffuse reflection." This is an excellent statement of the matter. It is analogous to transparency which is regular or to translucency which is diffuse. In measuring regular transparency, such as that of neutral tinted glass, it is sufficient to place a specimen in the path of a beam of light and to observe the effect upon the apparent candle-power of the source. But attempts to measure the absorption of ground glass and opal glass in this way have often led to the publication of erroneous results. The light scattered over a hemisphere must be taken into consideration, samples must be measured at different angles, and the whole sum must be calculated. In doing this, by any of the well-known methods, such as that of Kennelly or Russell's modification of Rousseau's curve, the flux over 2π is implicit, but we deal with candle-power all the time. Dr. W. E. Sumpner in his measurements of diffuse reflection and transmission* worked with the flux, with the result that his paper can only be read by those who have a good working acquaintance with integral calculus.

Since surface brightness consists of the two factors, illumination and the coefficient of reflection, and since brightness can be accurately compared and illumination can be accurately measured, this

* Sumpner, *Philosophical Magazine*, XXXV., 1893.

coefficient may be deduced without measuring flux as such, and without introducing the lumen into the work.

It is desirable that a distinction should be observed between the coefficient of diffused reflection of a substance and the summation factor of repeated reflection. In both cases it is desirable that the true coefficient or factor should be used, and not the arbitrary one which assumes that a certain card is perfectly white. In predetermining the result of a case of indirect lighting where the lamps are hidden and where a cove or ceiling becomes a secondary, and the only source of light, its value in a direction normal to the surface is its true brightness divided by π.

The U.S. Report contains a number of terms such as *Primary luminous standard, Reference standard, Working lamp,* and others which have fairly self-evident meanings.

Mean horizontal candle-power of a lamp is defined as "the average candle-power in the horizontal plane passing through the luminous centre of the lamp. It is assumed here that the lamp (or other light source) is mounted in the usual manner, or, as in the case of an incandescent lamp, with its axis of symmetry vertical."

"*Mean spherical candle-power* of a lamp—the average candle-power of a lamp in all directions in space. It is equal to the total luminous flux of the lamp in lumens divided by 4π.

"*Mean hemispherical candle-power* of a lamp (upper or lower)—the average candle-power of a lamp in the hemisphere considered. It is equal to the luminous flux emitted by the lamp in that hemisphere divided by 2π."

These three definitions are of great practical importance, and being practical, the corollary about flux, for it is nothing but corollary, might have been omitted.

In the case of all gas mantles and electric glow lamps, except perhaps those with a conical arrangement of filaments, the mean horizontal candle-power is a definite term and the one which will naturally be used by manufacturers in testing and marking, since it is generally the maximum. It would be difficult to induce them to use the mean spherical candle-power as an ordinary description even if any good reason could be found for asking them to do so. The present fashion of rating electric glow lamps in watts is a step in this direction, for the watts mean nothing to the layman, but if you give him the watts per candle you must give him horizontal or mean spherical candles.

In the case of arc lamps the mean horizontal candle-power is practically useless, and the choice lies between spherical and hemispherical; for the maximum candle-power which used to be given in a plain, commonsense way, is not likely to be revived. It is not much use for theoretical men to dictate to arc lamp makers how they shall describe their goods. All that can be done is to settle the definitions, and to invite them to agree upon some common usage.

It is somewhat characteristic of the U.S. Report that it defines the "spherical reduction factor of a lamp" as "the ratio of the mean spherical to the mean horizontal candle-power of the lamp," and sends the reader to a footnote, which informs him that in the case of a uniform point source this factor would be unity, which is fairly obvious, and for a straight cylindrical filament obeying the cosine law it would be $\pi/4$, leaving him to work out the value ·785398 to as many places as he likes on his shirt-cuff.

Symbols. It is generally assumed that there is an intimate connection between nomenclature or the drafting of definitions, and the symbols which are used to represent the terms and quantities, but there is no connection. To define a term clearly, completely, and concisely, is a matter of comprehension of the meaning, and of logical expression. To propose a symbol needs but a superficial acquaintance with the term to which it is to be applied, and logic interferes rather than helps, for general rules in symbology always fail as soon as they are propounded. The best way to start on the question of symbols is to have a good acquaintance with the usage of the leading writers who employ them, for some use few or none. By almost universal consent, candle-power or luminous intensity is represented by I, except by Germans, who do their best with J. The use of *cp* or *c.p.* is impossible

in a mathematical expression, but it is useful as a contraction, though it is purely English.

The symbol I_θ, the θ being used to distinguish it from a zero, has been suggested by Continental writers for mean spherical candle-power, $I_\cup$ for mean hemispherical candle-power in the lower hemisphere, and I for the upper hemisphere. The English contractions, MSCP, MHSCP, are very useful, though they cannot be used in mathematical work. The symbol I_h has been suggested for mean horizontal candle-power, and J-K or ⊢< for a Hefnerkerze, but it is hoped that the distinction between this and the candle-power will soon disappear.

The symbol for illumination adopted by many writers is E. A difference of opinion arises about flux. The small Greek ϕ has been suggested by the Verband deutscher Elektrotechniker and the Verein von Gas und Wasserfachmännern, but the International Electrotechnical Commission in their provisional rules recommend that small Greek letters should be reserved for angles. Of such letters, ϕ, θ, and ω are frequently employed for that purpose, and the I.E.C. propose the capital Φ for magnetic flux, with the alternative of script or sanserif or clarendon **F**. The U.S. Report suggests an ordinary F or Ψ, and further propose that in order to avoid possibility of confusion with electrical symbols, that symbols for photometrical quantities should be derived exclusively from the Greek alphabet, allocating Γ for luminous intensity and B for illumination. The I.E.C. adopt the italic *I* for electric current, it being customary to print mathematics in italics. The B for illumination is a bad choice, for there is no difference between the Greek and the Roman letter.

The nomenclature of the chief photometrical terms is ripe for settlement. Every foreigner who can read English should know what we mean by the word illumination, and every English-speaking man who can read French and German should know what is meant by éclairment and Beleuchtung. It is first necessary that these terms should have a well-defined meaning and that this should meet with general acceptance. This is one branch of science in which originality is not wanted; the word-coiner is too often a crank and a nuisance. Photometry and illuminating engineering have not sprung suddenly on the world like wireless signalling and flying. In such work the inventors must produce words to describe their discoveries and inventions. But we have a literature of a hundred years behind us. It should be our object to record what appears to be the general usage of the day rather than to guide the scientific literature of the future. In this paper the intention has been to make for lucidity and simplicity, without loss of accuracy, and thus to render the literature of the subject intelligible to a wider section of the public.

Discussion.

The President, in declaring the discussion open, said that several communications had been received from authorities on the Continent and in the United States, including Dr. Louis Bell, Professor A. Blondel, Professor Dr. Bunte, and Dr. Arthur Schuster, and he would call upon the Assistant Hon. Secretary to read these out to the meeting. Messages had also been received from Mr. Swinburne and Dr. A. Russell, expressing their regret at being unable to be present, but stating that they were in general agreement with the views set forth in the paper.

These communications were read to the meeting by the Assistant Hon. Secretary.

The President added that in the ensuing discussion attention might well be concentrated mainly on one point—the order in which it was expedient to settle the various units. It was important to begin with those definitions which ought to be taken first, so that the whole series would be built up on a logical plan.

Mr. C. C. Paterson: I wish to press home what Mr. Trotter has merely touched upon regarding the use of the term "candle-power." The paper has made me realise more fully than before the double sense in which the term candle-power is so often used. It is used as a conception of luminous intensity and also to express the numerical value of a source of light. In my opinion

candle-power should be used simply to express the conception, just as in the electrical analogy "current" is used to express the conception of flowing electricity. The term "candle" in light is equivalent to "amperes" in electricity so that just as we speak of "a current of 10 amperes" so we should speak of "a candle-power of 10 candles." It is very unfortunate that we cannot keep the term "candle" as the name of the unit and have an altogether different word to take the place of "candle-power." The Americans give another expression which I wish to speak about later.

On the main question of the paper, with all diffidence I am not sure that I agree with Mr. Trotter as to the order in which he suggests that we should consider these fundamental conceptions and units in illuminating engineering. Mr. Trotter says there is no need to consider "flux." We have a source of light and an illumination; let us be content merely with these two phenomena—cause and effect, and leave the conception of flux to those who want to bother about it. At first sight this sounds plausible, but I would like to give one or two reasons for disagreeing and for thinking that Mr. Trotter may be in error in suggesting that we should do this. The first point he urges is that the idea of flux is an obscure one to the ordinary individual, and that he cannot understand it. I do not agree. Even in advertisements on hoardings where different kinds of lamps are being advertised, a source of light is represented with streamers coming out in all directions. What are these streamers intended to represent but the flux of light from the light source, and if we ask any non-technical man to draw a source of light he is nearly certain to put in the streamers which he regards as the light coming from the source. An ordinary individual speaks of a lamp "shedding" light, or he speaks of opening shutters and letting in a "flood of light." This seems to me to show that the common everyday conception of light is that of a flux and not that of illumination.

The second point I venture to put forward is that if we try to get out definitions, leaving flux in the background, we shall immediately be compelled to bring the conception into our definitions, either actually or by implication, and it seems to me that in the paper Mr. Trotter has merely left out the word flux and called it illumination. For instance, in defining unit illumination he speaks of it as the illumination from unit candle-power "falling on" a surface. The conception of anything falling on a surface, whether it be illumination or energy, is the conception of flux, and thus Mr. Trotter has himself had to use the conception. Also in his very excellent book he has reproduced a diagram to explain illumination graphically and in which flux is the fundamental conception. Therefore, I really do not think it is possible to get rid of flux as the primary idea in light.

In the third place, if we look at all the other branches of physics, I believe I am right in saying that where radiation or its equivalent is concerned there is none in which the idea of flux is not the fundamental one. Take, for instance, sound, which is the most closely allied to light. If we do as Mr. Trotter suggests it is necessary to consider the sound which travels through the air as a negligible quantity and something which is not fundamental at all, but it seems to me that the sound in the air which actually reaches a person is the fundamental idea, and when the science of acoustics is developed I believe the energy or its equivalent which reaches the ear will be the thing people will want to know about and to measure and desire to think of as "sound" and not the bang or the commotion which produces it. Again, consider heat. The flux of heat, whether through a long conductor or through the air, is that which people think of as heat. Again, in the case of wireless telegraphy, we have to think of the energy actually travelling in the ether as the thing which it is desired to measure and deal with, and in electricity we consider only the current flowing, or the watts existing, in any network, and have ceased to think of the battery or generator producing it as fundamental. In magnetism it is the flux which constitutes the fundamental idea, and in electrostatics it is the field (which is equivalent to flux) which is the fundamental conception, and so with light I

suggest that we ought to keep our definitions on all fours with our definitions and conceptions in other branches of science. Radiated energy is always thought of, not as the source which is radiating it, but as the "something" which is passing through the ether towards us. Therefore, I venture to suggest that if we adopt Mr. Trotter's suggestion we shall be introducing an entirely new system into scientific definitions, and we ought to have some very good reasons indeed before deciding to do so.

We must be careful not to cause confusion by considering light as the energy itself. It appears to me that the convention of luminous flux bears the same relation to the energy which produces it, and which it may be regarded as accompanying, as, for instance, lines of magnetic flux bear to the magnetic phenomenon.

With regard to the American definitions and the use which the Americans have made of certain terms, I should like to make one or two observations. The expression "luminous intensity" is fixed on as the synonym of candle-power. I venture to think that the use of the word "intensity" in this connection is apt to convey a wrong impression. If we take two sources having the same candle-power but one ten times greater in size than another, the ordinary individual would certainly say that the small one had the greater luminous intensity, but according to the definitions he would be wrong. We want an expression which conveys the same idea as "luminous capability." I think it would be much better to avoid the use of the word intensity here and save it up for the definition of illumination. If we were to say that the "luminous capability" of a source of light is so many candles, it seems to me that we at once get the whole idea, *i.e.*, it is the capability of producing a luminous effect, and that is the idea one wants to get. However, I fear the use of the word capability is not as yet practical.

Again, in the definitions of illumination, I would suggest the use of the term "intensity of flux" instead of "flux density." This leaves out the mention of the word "density" in the definition, which has a very special meaning in other branches of science, and "intensity" allows of the conception of a flux falling on a surface and again radiating from it. I do not think we ought to think of illumination as a density. "Density" of flux in the middle of a stream does not convey an incorrect idea, but when we speak of flux density "over a surface" one has the mental picture of something which is piled up on that surface, and taken in conjunction with the conception of flux it gives the idea of the accumulation of flux on the surface. If on the other hand we speak of illumination as "the intensity of the flux incident on a surface" we are able to think of that flux not accumulating, but being absorbed or reflected as rapidly as received.

In any case, when formulating definitions in this way, I think it is most necessary in the first place to put down the exact truth no matter whether it is complicated, without assumptions and without short cuts towards simplicity. When we have all our definitions fixed in this way, and free from confusion, we can then begin to consider simplification and shortening for the use of the every-day engineer.

Mr. Haydn T. Harrison said he thoroughly agreed with Mr. Trotter's views as set out in his paper. The first thing ever worshipped, he believed, was the sun itself, and he presumed that the people were worshipping the light source and not the flux. He could not help thinking that a person to-day, going into an artificially-illuminated room, noticed the light source, but knew and thought very little about the flux. There would be a great deal of difficulty in impressing the idea of flux upon the average man.

Mr. Paterson had referred to illustrations, showing streamers or radial lines, and maintained that these represented flux, but he did not agree with this. The oldest pictures of the world showed light in this way, and in his opinion all that was intended was to give an impression that the source was giving forth a strong light.

He congratulated Mr. Trotter upon aiming at simplicity. There was often too much complication in other branches of science and engineering, but illuminat-

ing engineering was a young science and should be kept free from needless complexities. In engineering the term "horse-power" was still in general use, despite the fact that it was no more appropriate than the word candle-power, but it still remained the basis of all engineering power calculation, just in the same way as candle would remain the basis of illuminating calculations. Therefore he believed there would be as much difficulty in removing "candle-power" from this science as there would be removing "horse-power" from mechanical engineering. It was necessary to make the terms as simple as possible to the average man, and he was very glad that Mr. Trotter had put the matter forward from this point of view.

Mr. F. W. Goodenough, in reference to Mr. Paterson's suggestion of luminous capability, said that if "luminous power" was used it would be nearer to the commonly accepted expression of candle-power than any other expression. We could then say that a light had a luminous power of so many candles.

Mr. W. C. Clinton said he was rather inclined to agree with Mr. Paterson, that most people think in terms of luminous flux instead of candle-power, as even yet we spend most of our waking hours in light derived by reflection from extended surfaces.

The design of commercial electric machinery of all descriptions is based on a proper comprehension of the behaviour of magnetic flux, to the practical exclusion of the older method of dealing with magnetic pole strength. Magnetic flux and flux density, from being an idea familiar only to a few, have become of necessity the commonplace of dozens of drawing offices, where magnetic intensity would hardly ever be spoken of, and in the same way, luminous flux and luminous flux density must come to be used in the commercial lighting work of the future.

The notion of candle-power as a directed intensity will, however, always remain as a valuable derivative without which it would be difficult to make quantitative comparisons of different artificial light sources.

Mr. Edward Allen said the paper was a very valuable contribution to the literature of photometry; and in his opinion demonstrated once more the value of the Illuminating Engineering Society. As those present were aware, there was an attempt to arrive at international unity in this matter of the measurement of illumination; and the British members of the International Committee would find Mr. Trotter's paper a valuable help in considering their attitude at the coming Conference. Just lately some consideration had been given in the House of Lords to the abolition of a standard test for the illuminating power of gas, and he was glad to say that this was being replaced by a calorific test. It would still be necessary for attention to be given to the nomenclature and definition of photometric magnitudes and units as dealt with by Mr. Trotter, and in that connection illuminating power was of great importance.

Mr. K. Edgcumbe said he was not sure that they were all quite clear from the paper how far this suggested change of definitions would really affect the "man in the street," who had been so much spoken of by Mr. Harrison and others, and who really was a most important factor. If those who were trying to sell lamps had got to speak of a "solid-angular flux density" he was afraid it was going to be rather a serious matter, but if they could still speak of a lamp as giving a light of so many candles, then, from his point of view, he was not sure that the change was going to be so very serious, and it could, perhaps, be left to the men of science to settle which way they would express themselves. Personally he would much prefer to begin with candle-power, in spite of Mr. Paterson's views as to poster artists. At the same time he must admit that Mr. Paterson had to some extent converted him with his analogies from other sciences.

Prof. J. T. Morris :—

Logically, I suppose that it would be wise to take as the fundamental unit a definite expenditure of energy distributed throughout the visible spectrum in

accordance with a standard curve which would need to be fixed by mutual consent.

Another method might be based upon the "mechanical equivalent of light."

But these, and many others like them, are practically incapable of being realised—at any rate with our present state of knowledge.

If, as I am convinced, for the present we cannot define usefully from energy considerations, then I am in complete agreement with Mr. Trotter in that it is best to take as one's starting point candle-power, because I believe it to be best understood, and also because the approximate magnitude of one candle is appreciated by many people.

It has the objection that when the candle is defined as one-tenth of the Pentane Standard that it may be of more use for seeing purposes for some than for others, and it is conceivable that with the lapse of centuries the wave-length range of the human eye might alter, so that the standard of light might yield no visible light at all! But exactly the same objection can be urged against the energy definitions.

Hence for the present I am convinced that it is best to start from candle-power, though perhaps as a tentative measure.

Mr. W. J. A. Butterfield said that when Mr. Trotter read his paper he was thoroughly at one with him, but Mr. Paterson had now almost converted him to his point of view. When Mr. Paterson stated that candle-power was indefinite, and that it was necessary to say a candle-power of so many candles to make the expression complete, it reminded him that no use had been made in these definitions, or in Mr. Trotter's paper, of the old expression "illuminating power," to which, indeed, there were many objections. On the other hand, however, there would not be tautology if one spoke of an illuminating power of so many candles. Nevertheless, he agreed it was an objectionable term, and would ask whether the expression "illuminative value" was not a good alternative to "luminous intensity" or "candle-power." It was an expression which he believed originated with Dr. Vernon Harcourt, a very clear thinker of the old school, and there was much to be said for it.

Mr. J. Darch said that he was pleased to note that Mr. Trotter's paper confirms the correctness of a series of definitions which he had published about two years ago.* He thought that for the practical purposes of the ordinary engineer such definitions should be terse and concise. He hoped that Mr. Trotter's paper would receive very careful study, because so many people engaged in the lighting business misunderstood the real meaning of the words they used. In dealing with the technicalities of illumination it is particularly desirable that people should be exact in their choice of words. For example, "Surface Brightness" "Intrinsic Brilliancy," "Luminosity," and "Luminous Intensity" each have a distinct application and should find their proper place in our intercourse. He would also like to emphasise the fact that the term "illumination" refers to the light *falling upon* any surface; he had defined it as "the light falling upon any surface—the flux density—irrespective of the absorbing powers of that surface." The illumination received by a surface was thus exactly the same, whether it fell upon black velvet or white paper, although the result was very different. He thought that some people in speaking of these matters confused the brightness of the surface with the illumination received.

Mr. W. J. Liberty said he hoped Mr. Trotter would give some consideration to the term suggested by Mr. Paterson—"luminous capability."

Mr. V. H. Mackinney said that there were two distinct points of view to be taken with regard to these definitions. From the practical standpoint he agreed with Mr. Trotter. From his experience he was aware of the difficulty of presenting data in terms of "flux of light" to the ordinary public. In this respect he thought it would be long before the term "candle-power" could be superseded, and in many respects this was at present the more convenient quantity to use.

* Journal of the Society of Architects, February, 1912.

But from the purely scientific standpoint he would side with Mr. Paterson. He was inclined to think that flux was better suited for precise scientific definition than candle-power, and might be the best unit to start from.

Turning to another matter, he agreed with Mr. Trotter that a fair amount of latitude should be left to manufacturers in describing the light yielded by their goods. This had been recognised by a Committee of the German Illuminating Engineering Society, who had just issued an interim report on the subject. The Committee suggested that either mean spherical, mean lower hemispherical or mean horizontal candles should be given; but that if the mean spherical candle-power is not given the reduction factor, enabling this quantity to be determined, should be supplied. They further recommended that it should always be clearly stated which of the above three quantities was intended; for this purpose the symbols I_o I_u I_h so widely used abroad deserved to be more generally known.

Mr. Trotter's remarks on reflecting power and absorption applied to surfaces. He would like to point out that the reflecting power or absorption of globes and shades was often determined by quite different circumstances (*e.g.*, by whether the shade was a deep or a shallow one). Before long it would be necessary to come to a more definite understanding how the reflecting power and absorption of shades and reflectors should be expressed and measured.

Mr. Beuttell agreed with Mr. Mackinney that the lumen was a very convenient unit to deal with. He saw no objection to the notion of flux, which was a thing everybody was familiar with in electrical and scientific calculations of every kind; everybody was familiar with flux density.

There seemed to be a tendency to confuse the meaning of the words "intensity" and "density." "Density" to his mind had a perfectly clear meaning, namely, it was a quantity whose denominator was an area. "Intensity" had no such meaning.

Siding as he did with both points of view which had been expressed during the discussion, he did not see that there was any suggestion that we should do away with either the candle or the lumen. He would be very sorry to do away with either, and on this point he agreed with Mr. Mackinney that candle-power should be used for ordinary commercial purposes, and flux for technical purposes. He believed the Americans retained the idea of the foot-candle, the lumen, and the flux.

He had been giving attention to a matter lately which was not likely to simplify matters, but rather to complicate them; and that was that some day we might require to measure illumination subjectively as well as objectively. There was the old definition of light as the stimulus which excited vision. Mr. Paterson, for instance, had spoken of the flux, *i.e.*, the energy, or really the light emitted from the source, which meant that there was energy in the form of some kind of flux which, when it reached the eye, stimulated the nerves and excited vision, and it was not until we got to that point that we had the notion of light.

This brought us to a consideration of the term "brightness." There was an illumination, the measure of the flux, or whatever it was called, received on the surface. Then we had brightness as the measure of the luminous flux given off in return from that surface, following which there was another quantity, namely, the magnitude of the brightness sensation as judged by the eye, and for that reason we might have some day to measure illumination subjectively. When we got to that point we should have to use the term "subjective brightness" as opposed to objective brightness, or, in other words, the subjective or physiological measure of the light given off from the surface as opposed to the objective or physical measure of the light received on the surface. Otherwise we should have brightness meaning two things, namely, the objective and the subjective brightness respectively.

The President, referring to the pamphlet of the American Committee, said that he regarded the half-dozen paragraphs of the first page as mere preamble, and pointed out that so soon as they came to

definitions the first matter which they defined was a concrete thing—*the candle*. Essentially, therefore, they agreed with Mr. Trotter in defining the concrete unit first. Referring to the discussion as to the meaning of the words "intensity" and "density," he agreed with Mr. Beutell that "intensity" conveyed to the ordinary mind an idea different from that of "density." Supposing, for example, that there were a lamp hung up opposite a wall, it would throw a patch of light which was not uniform all over, but was more concentrated towards the middle, and less bright towards the distant parts. Would not the ordinary person say that the illumination was more intense in the middle? But the ordinary man would not think of that as "density." He did not believe anybody would think of the light as being more "dense" at a particular place than at another. The word "intensity" should not be used except as expressing a kind of relative value.

There were some expressions in the paper, taken from the American report, which might be made clearer. It was stated that "a uniform source of one candle emits 4π lumens." But what was meant by "uniform"? He, the speaker, supposed that it meant a sort of imaginary candle which was of one candle-power when looked at from every aspect—from the top or the bottom, or right or left; but such a candle had never existed anywhere. But the term "uniform source" might mean quite a different thing, namely, the British standard sperm candle, burning uniformly 120 grains per hour. Clearly the word "uniform" needed better definition. If the intention was that people reading this statement were to understand that it was uniformly of one candle-power from whatever aspect, then it should be so expressed. He had been trying to realise how much a lumen was, and had deduced from the American definition that one lumen was $1/4\pi$ of the whole light emitted from a spherically uniform source of light giving one candle in every direction. He did not see how to arrive at any shorter definition if it was to be exact. If, however, on the assumption that the lumen was a heaven-sent unit, they then were to proceed to define "one candle," the definition would run as follows:—"One candle of uniform light is a source which emits 4π lumens"; or it might be expressed as follows:—"A source which emits one lumen per sterean in any direction is of a power of one candle in that direction." Supposing one went to a clever optician, or, let us say, super-optician, and asked to be supplied with one lumen, what would the optician have to do to fulfil the order? He would have to provide a pyramid or cone, a thing looking like a gramophone mouthpiece, constructed to enclose a solid angle of one sterean, and then at the apex he would have to put a source which would emit exactly one candle-power into that conical shade. Then we should get one candle per sterean, and he supposed that would be the "one lumen" desired. It ought to be; but he was not quite sure it would be. He would like to put this question to the audience: Supposing one had a 10-lumen lamp, how many candle-power was it? He would leave the members to think the answer out for themselves; and they would find that the problem was indeterminate. We were, in fact, not habituated to think of light in that way, and it would take a very great deal of practice to change our language, because we should also have to change our mode of thought. It was because of this that Mr. Trotter, and the American Committee itself, were amply justified in starting from the candle as the unit of luminous intensity as determined by the national laboratories of England, France, Germany, and the United States.

Lastly, there had been some discussion about the difficult term "emissive brightness," or "illuminative value." For his own part he would much prefer the word "luminosity." The circumstance that Sir William Abney had used that term in a specific way about the brightness of different parts of the spectrum should not prevent anyone from using it in a more general sense. The only other possible rival term was "lucidity," which was scarcely available.

Dr. Arthur Schuster (Secretary of the Royal Society) (*communicated*):—

I am sorry not to be able to be present at the meeting of the "Illuminating Engineering Society," but should like to express my entire concurrence with the

general principles which Mr. Trotter has embodied in his paper. The difficulties which are met in defining clearly terms in any subject are aggravated by the fact that the need for accurate definitions generally arises only when the subject has reached a certain importance. In the meantime, a loose kind of nomenclature has been adopted, and the choice often lies between altering the meaning of words already in use or introducing an altogether new set of terms. I think it is a good principle not to define too closely words which are in common use, unless the question of measurement comes in. The word "light," for instance, has several distinct meanings, and it would be a pity to confine it to one of them only, even if it were not altogether impracticable. I do not think that there are enough words in all the languages of Europe, with the addition of Latin and Greek, if each word is to be used in one definite sense only.

Strict definitions are necessary in all conceptions which are to be reduced to measurement; they are to be avoided where they only aim at substituting an uncommon word for a common one. Take, for instance, the first definition quoted in the paper:—

> "Luminous flux is radiant power evaluated according to its capacity to produce the sensation of light."

The reader is here supposed to be ignorant of the meaning of "luminous flux," but to have an accurate conception of "radiant power." This does not seem to me to be helpful.

I agree further with the author's treatment of "candle-power," and I can see no objection to the use of the word "candle" as a unit. The only object of language is to make our meaning clear to others, and once a term is properly understood in a definite sense, it is no use to enter into an etymological inquiry whether the word is really an appropriate one. I should meet Professor Blondel's objection by saying that if a great many stoves gave out approximately the same amount of heat, and if the word had come into common use to express even roughly a certain amount of heat-giving power, I should see no objection to using the word "international stove" as a unit. It is all a question of policy whether it is better to invent new words or to alter the meaning of existing ones. In the use of "light" we want to retain a word which has a physiological, a physical, and a technical meaning, and its use is so common that a strict definition confining its meaning would have no chance of being adopted. In the use of "candle" there can be no confusion, and it is a short and convenient word.

I am not sufficiently familiar with the technical point of view to enter fully into the various questions dealt with by the author, but his authority in these matters should carry weight.

I am interested in the question of symbols, but it seems to me to be a most difficult one, and cannot be treated very shortly. I must confine myself therefore to expressing the hope that the use of initials may be restricted as much as possible. I cannot see, for instance (*not* e.g.), why we should not always write "candle-power" in full instead of c.p., and I do not think I have ever written E.M.F. for electromotive force. Those who constantly have one subject in their minds sometimes forget that what is self-evident to them is not always intelligible to others. Abbreviation by initials is rapidly becoming one of the most irritating incidents of life.

Dr. Louis Bell (BOSTON) (*communicated*):—

I have read the paper with great interest. I must own that I have considerable sympathy with Mr. Trotter's criticism of the highly scientific, but, in my personal opinion, unnecessarily intricate system of nomenclature proposed by our American committees, on some of which I had the pleasure of serving. My own feeling, as freely expressed to my colleagues, is that, while the propositions viewed a decade or two hence will perhaps seem both logical and far-sighted, they need great simplification before they can be adopted for the everyday work of illuminating engineering. I do not believe in adopting a new unit or a new symbol until it becomes vitally necessary to a common understanding of the subject. I do not think that a new nomenclature should be promulgated merely because a lecturer is lazy with his chalk and wants a new symbol

to save himself five minutes per year at the expense of his hearers and the public at large.

I have, however, little doubt that the present propositions will, as a matter of practice, settle down into some reasonably simplified form, although many of the items may go to swell the curious historical collection of unused and impracticable units laid away in the archives of various learned Proceedings. I think, however, that it is an excellent thing to have made a conscientious attempt to bring the nomenclature of illumination into line with general scientific nomenclature, even although for practical purposes much of it may be laid aside.

Perhaps I can clear up Mr. Trotter's difficulties at one point, that of the double definition of brightness, which was the subject of long debate in the Committee. The two definitions are not quite what Mr. Trotter indicates. "Brightness" is used to denote the luminous intensity of the projected area of the surface considered, taken just as one finds it from the position of observation. "Normal brightness" is the corresponding intensity normal to the element of the surface considered. The first definition is the only one ordinarily used in specifying the intrinsic brilliancy of a source as seen. The second definition is the theoretical intrinsic brilliancy considering the normal surface only and has, I think, very little practical bearing in ordinary usage.

Perhaps this is sufficient comment on the matter from my view-point. As you will see, I think our Committee report is a workmanlike and scientific job which has been somewhat overdone as to details. It is, nevertheless, a good thing to have on record to correct the loose terminology, now altogether too common.

Professor A. Blondel (PARIS) (*communicated*) :—

I have read Mr. Trotter's paper with the greatest interest, and I appreciate very much the courteous reference which he has been kind enough to make to my work on the photometric units and symbols.

As the author of the report of 1896* and as a collaborator in the work of the Commission of the American Illuminating Engineering Society, I hardly feel myself in a sufficiently impartial position to discuss this paper in great detail.

Moreover, my long-established, intimate and friendly relations with Mr. Trotter render it hard for me to assume the position of a practical critic in dealing with those points on which we differ. But I may remark that he seems to be committed to a conservative outlook which is somewhat in contrast to that adopted by the American Society and by other societies in foreign countries. I may perhaps mention that the views of the American Society have been officially accepted by the Société Française de Physique, and the report recently published by the Société des Electriciens makes use of these suggestions, with some slight modifications in detail.

The American Society, in whose work I have taken part, aims at establishing a system of photometric units and symbols which should be: (1) *Scientific*, that is to say, in direct and intimate relations with other branches of physics and carried to the same degree of scientific precision; (2) *International*, that is to say, containing terms capable of being adopted for all countries.

It is for these reasons that it has been found impossible to adopt the word "candle-power," which, although made venerable by years of usage in England, is completely unknown in other Anglo-Saxon countries. For the rest the photometric system should be framed to meet the requirements of science, and not to comply with the old-fashioned practices dating from the early days of public lighting, nor to meet the views of those who, as Mr. Trotter says, "know little or nothing about angles and flux." On the contrary, the system should be *in advance*

* These suggestions are really based on a rational system of units which I brought forward for adoption at the International Electrical Congress at Geneva in 1896, but our friends in America have embodied in them some impressions which lead to greater scientific precision. For example, they have substituted a centimetre for a metre in order to bring the definitions in line with the C.G.S. system.

of its time. It should provide engineers with scientific ideas of illumination and conceptions in harmony with the progress of other branches of physics. It is for these reasons that it is necessary to define luminous flux (a special form of energy) before proceeding to define the source of light. Moreover, the definition of a luminous source is not rigid except when the source in question is a *point*. Mr. Trotter, who has doubtless read the first section of the Geneva report, will have noted the remark that light was created before the stars; similarly, it is right that we should consider the flux of light before the source of it.

The conception of a flux is so convenient in practical lighting problems, both as regards interior and public lighting, that people have come to make constant use of it, and in fact can hardly avoid doing so (see for example Treaties on Illumination, by Dr. L. Bloch). And how is it possible to define illumination in a scientific manner without recourse to this quantity?

Moreover, by adopting this scientific conception one finds that it is not necessary to draw a distinction between primary and secondary brightness. If we observe in succession the sun and the moon we realise that both act as sources of light. Why, therefore, assign to the sun primary brightness and to the moon secondary brightness (I may remark that in France the word *éclat* has now a different significance, and brightness is usually expressed by using the word *brillance*). I have also shown previously in the course of a more complete discussion that the conception of secondary brightness introduces inconvenient and useless complications, and is quite unjustifiable. Here, I think, I shall find myself in agreement with Mr. Trotter.

But it *is* necessary to distinguish between the brightness in a direction perpendicular to the surface and the brightness in oblique directions, for there are few bodies which follow Lambert's law exactly.

Finally, I wish to set aside all criticism of detail for a moment and to express my enjoyment of the very competent and ingenious treatment of this subject which one has learnt to associate with Mr. Trotter. I have read the paper with the keenest interest and appreciation, and I hope that after a time that he will convert himself to the propositions referred to, which are required to satisfy the requirements of scientists throughout the world.

Professor Dr. H. Bunte (KARLSRUHE), (*communicated*) :—

Mr. Trotter has found in the proposals of the American Illuminating Engineering Society an excellent opportunity of raising discussion on this important subject. He weighs in the balance the practical and theoretical aspects of the subject and finds himself on the side of the former.

It is known that the American proposals are in agreement with the conclusions of the International Electrical Congress held in Geneva in 1896 (associated with the work of Professor A. Blondel), that the Flux of Light should be regarded as the fundamental quantity and the candle-power and Illumination derived therefrom.

Mr. Trotter expressly recognises that there is nothing to be said against the American proposals on the ground of logic and precision, but he contests their practical value, and endeavours to show that the Candle-power is scientifically desirable, and from a practical standpoint it is decidedly preferable as the fundamental quantity.

I appreciate fully the practical standpoint of Mr. Trotter, and I agree with him that light should not be defined as a purely subjective phenomenon. As a matter of fact light-rays constitute radiant energy and follow all the laws by which such radiation is governed. It is only the physiological effect of the sensation of light that is subjective, and this should be made quite clear.

On the other hand I do not agree with Mr. Trotter when he takes exception to the Blondel system, as embodied in the American proposals. For our object here is to lay the foundations for international agreement on a purely scientific subject, and to bring about clearness in the technical expressions involved, so that they may be intelligible alike to scientific men and to those engaged in the industry. In this case the impressions of the layman and the convenience of "practical men" occupy a secondary

position. Yet no special difficulty would be experienced by them as a result of the proposed understanding. For their methods of measurement will remain the same as before. To understand the new method of presenting the photometric quantities is by no means such a difficult process as Mr. Trotter seems to think (as I can testify after teaching these subjects for years).

A fact that will hardly be disputed is that the use of the Flux of Light cannot be avoided in the scientific treatment of photometry. If we assume the Flux of Light, the conception of Intensity of Light follows quite naturally. This conception of Intensity of Light is thus somewhat different from that which the practical man designates as "candle-power"; but the definition gives in my opinion the only means of bringing the photometric quantities into relation with one another on a satisfactory basis.

I am therefore in complete accord with the Blondel system as the basis of international agreement and as embodied in the American proposals, which are in substantial agreement with those prevailing for a long time in Germany. The only distinction is that here the metre is adopted as the unit of length and the hour as the unit of time. There are also several expressions which were formerly used, but have now become obsolete in practical photometry, or have been invested with a more specialised meaning. Among these may be mentioned the word "Leuchtkraft," and also the word "Helligkeit," which is now only applied to the retinal image in the eye.

Mr. J. S. Dow (*communicated*) :—

Mr. Trotter's paper illustrates the old difficulty of compromising between theoretical excellence and practical convenience. Any steps affecting everyday photometry and illuminating engineering must take place gradually. There are methods which, although scientifically not rigidly correct, are so convenient that they will not readily be displaced.

A case in point is the secondary system of defining surface-brightness. I have always considered this a very convenient method, and have frequently expressed the brightness of walls and ceilings and the sky in foot-candles. In daylight work, where one is constantly relating indoor illumination to sky-brightness, it is particularly useful. For example, if the sky-brightness is expressed in foot-candles, it is equal to the "unrestricted daylight illumination" on a horizontal surface receiving light from the entire hemisphere. Therefore, if we measure the illumination on a school desk and then the sky-brightness (both in foot-candles), the ratio between them gives us at once the desired "daylight ratio" for the room. This method has been widely used in researches on school planning in Germany, and it would not be convenient to drop it completely. Yet I recognise that from the scientific standpoint there are elements of unsoundness in this method of defining surface brightness, and it might justifiably be omitted from international nomenclature, even though for a time it would still be used for certain classes of work.

Mr. W. R. Cooper (*communicated*) :—

I should like to support Mr. Trotter's views on the general grounds that, unless there are strong reasons to the contrary, units should be chosen so that they are simple and self-explanatory. Otherwise they do not readily come into use. The term "candle-power" has been in use for years and people are familiar with it. Similarly, the term "foot-candle" for illumination is one that is both easily grasped and of which a quantitative idea is easily formed. On the other hand, the term "lumen" is not so easily grasped, and a working knowledge of it is not so easily gained. Such units, therefore, will be avoided by most of those who handle problems of illumination.

Mr. J. W. T. Walsh (*communicated*) :—

It seems to me that during the course of the discussion which followed upon Mr. Trotter's valuable paper, as well as in the paper itself, the physiological nature of light as its fundamental property did not receive quite the degree of attention it deserved. In fact, a tacit, if not wilful, disregard of this, the great factor distinguishing photometry from all purely physical sciences, led several speakers into a somewhat false position. Thus, at

least one speaker supported his arguments by an appeal to the analogy of the purely physical sciences of electricity and magnetism. Surely it is clear that in such cases as these all measurements are ultimately made by purely mechanical means, whereas in light such methods are and must ever remain impossible except as matters of convention, for in the case of light the ultimate measurement must always depend upon the eye.

In such a case it appears that some convention such as the following must ultimately be adopted. Let it first be conceded that all normal eyes are sufficiently alike in their behaviour to cause no *serious* difficulty in practical measurements, and then, acting on this assumption, a standard instrument such, for instance, as a perfected form of the photo-electric cell and filter system of Dr. Voege may be designed (and so specified as to be readily and accurately reproducible) to behave approximately as the *average normal eye*. Once this conventional secondary standard has been universally agreed upon, the ultimate measurement ceases to be physiological and becomes physical. In consequence the treatment of light measured in this manner may proceed on lines exactly analogous to those used in other physical sciences. Thus instead of taking, as at present, the source as the ultimate unit in photometry, illumination will naturally take its place, being, in the case of the photo-electric cell instanced above, defined as that illumination which produces a given current in the standard cell. From this all the other units may be readily derived.

[We have also received letters from PROF. A. E. KENNELLY (Harvard University, U.S.A.), PROF. DR. J. TEICHMULLER (Karlsruhe), and MR. M. LUCKIESH (Nela Research Laboratory, Cleveland, U.S.A.), mentioning their intention of taking part in the discussion later on.

Among others who have written expressing their interest in the paper we may mention DR. A. C. HUMPHREYS (President of the Stevens Institute of Technology, U.S.A.), DR. E. P. HYDE (Nela Research Laboratory, U.S.A.), DR. BRODHUN and DR. E. LIEBENTHAL of the Reichsanstalt, Charlottenburg), MR. P. S. MILLAR (New York), and SIG. M. BOHM (Milan).—ED.]

Mr. A. P. Trotter : Prof. Blondel has referred to the Report which he presented to the International Congress at Geneva in 1896, and I have turned to the copy which he sent me with his compliments eighteen years ago. In discussing this matter he wrote : " The only question which arises and of which the interest is purely philosophical is to know in which order we should link the definitions of these different magnitudes, that is to say, which one should be taken as the primary magnitude." Philosophy is indispensable in connection with the foundations of pure science, it is of doubtful use and sometimes disconcerting when mixed with applied science, and it is altogether out of place when dragged into technology and engineering. But French thought remains elegantly philosophical where English ideas are crudely empirical. To an engineer these nice distinctions of order are like disquisitions on cause and effect, and remind one of the theorem that a hen is the method adopted by an egg for producing another egg.

I have had grave qualms of conscience in advocating a point of view which might be held to be unscientific. The object of the present discussion is to arrive at the most useful photometric quantities and to define them. Usefulness in this case is not antagonistic to scientific precision.

We have systems of measurement which include the imperceptible dyne and the tiny erg ; the electrostatic units of the lecture room and the electromagnetic units of the laboratory, in which we define electric current as $L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$. But when we get to work we use an ampère which is 1/10, and the volt which is 10^8 of the C.G.S. units, and we drop the centimetre and use the millimetre or metre.

The Geneva report contains two tables, one of magnitudes (dénominations des grandeurs) and the other of units. The first is in the following order. Quantité de la lumière; Flux lumineux; Eclairement; Intensité ou puissance lumineuse; Eclat (intrinsèque); Rayonnement ou éclairement intrinsèque. The units in the second are arranged thus: Intensité; Flux; Eclairement, Rayonnement; Eclat; Quantité de la lumière. Prof. Blondel's further experience has led him to modify the first, and to produce the U.S. table. I wish slightly to modify the second and to suggest the following, and see no reason why both sets should not be recognised.

Magnitude.	Unit.	Definition.	Symbol or contraction.
a. Candle-power *b.* Illuminating value *c.* Luminous power	Candle .. Hefner ..	One-tenth of Pentane standard Hefner lamp.	*I* H.U.
Illumination	*a.* Foot-candle	The illumination received from a source of one candle falling perpendicularly on a surface at a distance of one foot from the source.	$E=I/d^2$
	b. Candle lux.	. . . distance of one metre . . .	
	c. Hefner lux.	. . . Hefner . . . one metre . . .	
Flux	Lumen ..	*a.* The flux emitted in unit solid angle by a point source of one candle. *b.* The candle-power of a point or spherical source multiplied by 4π.	*F.*
Brightness or Brilliance	—	Candles per square inch (or sq. mm.)of apparent self-luminous or illuminated surface. In the case of diffused reflection it is equal to the illumination received multiplied by the coefficient of diffused reflection.	*B.*
Mean spherical candle-power	—	The mean candle-power of a source in all directions. (Total flux divided by 4π.)	M.S.C.P.
Mean horizontal candle-power	—	The mean candle-power in the horizontal plane of a source mounted in the usual manner.	M.H.C.P.

Prof. Blondel has objected to "candle-power," and the discussion has elicited several substitutes. On the day following the meeting I wrote to a manufacturer about some lamps, and used the expression "illuminating value" two or three times, but although he had been present at the meeting I thought it necessary to explain that I merely meant "candle-power." Prof. Blondel tells me that I am committed to a conservative outlook. I am so conscious of my intuitive conservatism and of the wildly radical world in which I live, that I am ready to throw away the "candle-power" as an old-fashioned relic if I am sure that English science and engineering will benefit by using a substitute. So I leave it as the quantity of which the candle is the unit, I have added the Hefner which we all recognise, and which some of us use (screwed up to 43 mm. to give a candle).

I follow with the foot-candle, and when we can all agree to screw up our Hefner

lamps this may disappear and the lux may take its place.

Then comes the lumen, which I neither disparage as a theoretical quantity nor underrate as a practical unit. The U.S. Committee are fully justified from their scientific point of view in adopting it as the primary quantity. Although the science and art of photometry had advanced greatly in the hundred and fifty or two hundred years since Bonguer and Lambert made the start, the need for the lumen had not been felt until Prof. Blondel introduced or indeed created it in 1895. In the technical practice of lighting problems of the present day the lumen is indispensable; for so far from being a complication it is the most convenient mode of expression in certain cases, such as for interior work or for average values in street work. It is no objection to the lumen that there is no advantage in saying that a lamp gives 202 lumens instead of 16 candles; that is not what the lumen is wanted for. "Photometry is only complete," says the Geneva report, "if it permits the evaluation of the flux of light which enters through a window exposed to the sun." For purely practical purposes I have given two descriptions or definitions of the lumen.

I welcome Prof. Blondel's support in abandoning any distinction between primary and secondary brightness. I am tempted to go a step further with him, and to propose to use the word brilliance which is perfectly applicable in English, and has the advantage of being identical with the term now used in France. Conservative as I am, I will make the change if others will. We have all changed from the candle-foot to the foot-candle in the last eight years, though it was difficult.

I agree with Prof. Bunte that the impressions of the layman and the convenience of practical men must occupy a secondary place when it is proposed to lay the foundations for international agreement, and I hope that nothing in my paper will impede that result.

The opinion of the majority of those who took part in the discussion was supported by all the editorial comments that I have seen in the technical journals, and the only serious objector to my criticism of the order of the U.S. definitions was Mr. C. C. Paterson. I perceive that I have overstated my case, for he observes: "Mr. Trotter says there is no need to consider flux," and Prof. Bunte says that "the use of flux of light cannot be avoided in the scientific treatment of photometry." My remarks on the lumen are, I hope, a sufficient reply to this. The conception of the lumen is of importance, and the chief use of the conception of flux of light is to enable us to understand what is meant by a lumen.

Mr. Paterson accuses me of mixing up flux with illumination. I see how this has arisen. My original definition of the foot-candle was "The illumination received from a source of one candle-power falling perpendicularly on a surface at a distance of one foot from the source." Here the idea is that of "one candle-power falling," &c., meaning the light of one candle-power. But I try to avoid the use of the word light, for we get into deep water if we attempt to define it. I had, however, substituted the word candle for candle-power, and since it is not intended that the candle shall fall on the surface, Mr. Paterson rightly suggests that the only other thing left to fall is the illumination. I accept his criticism, and am inclined to substitute the word light for the word source, and to decline to define "light" just as I decline to define temperature or time.

I agree with Mr. Paterson about the terms intensity and density, and think that they are redundant in connection with illumination.

Prof. W. C. Clinton and Mr. Mackinney agree with Mr. Paterson in giving the first place to flux, and Mr. W. J. A. Butterfield was "almost converted" by him. If we have four recognised systems of electrical units, the dimensional C.G.S., the electrostatic, the electro-magnetic, and the practical, there is precedent for more than one set of photometric units, namely, the U.S. set, professedly theoretical and scientific, and some such set as I have suggested, which attempts to be practical without any scientific or philosophical sacrifice.

INTERIM REPORT ON THE DAYLIGHT ILLUMINATION OF SCHOOLS.

(Issued by the Illuminating Engineering Society with the approval of the Council and of the delegates of the Associations represented on the Joint Committee, appointed in 1911.)

In 1913 an Interim Report on the Artificial Lighting of Schoolrooms was issued by a Joint Committee* constituted as follows:—

Prof. W. C. Clinton, Mr. J. Darch, Dr. W. Ettles, Mr. F. W. Goodenough, Dr. H. R. B. Hickman, Dr. J. Kerr (*chairman*), Mr. W. R. Rawlings, Mr. T. E. Ritchie, Mr. A. Stokes, Mr. S. E. Thornton, Mr. P. J. Waldram, Mr. R. J. Wallis-Jones representing the Illuminating Engineering Society.

Dr. R. S. Clay, representing the Association of Technical Institutions.

Dr. J. H. Vincent, representing the Association of Teachers in Technical Institutions.

Mr. E. S. Mortimer, representing the London Teachers' Association.

Dr. E. H. Nash, representing the Medical Officers of Schools Association

Dr. N. Bishop Harman.

Ex-officio.

The President (Prof. S. P. Thompson), Hon. Secretary (Mr. L. Gaster), and Assistant Secretary (Mr. J. S. Dow) of the Illuminating Engineering Society.

In that Report it was stated that the Daylight Illumination of Schools was also being considered. In view of the complex and technical nature of the problem involved a Sub-Committee, consisting of Mr. W. C. Clinton, Mr. J. S. Dow, Mr. L. Gaster, Dr. James Kerr (Chairman), Dr. E. H. Nash, and Mr. P. J. Waldram, was appointed to deal with the subject.

One of the first tasks undertaken by the Committee was to draw up a list of points on which further information was required. A considerable number of photometric tests of daylight were carried out by various members of the Committee, chiefly in the course of visits to several schools in London and elsewhere. The Committee desire to express their special appreciation of the courtesy of the Wimbledon and Derbyshire Education Committees in affording opportunities for the inspection of schools in these districts.

Eventually it was thought desirable to supplement these researches by an open discussion on some of the most debatable points, and a paper was accordingly prepared and read at a meeting of the Illuminating Engineering Society by Mr. P. J. Waldram, one of the members of the Committee.*

It was recognised that certain aspects of school lighting had been exhaustively studied on the Continent, and a summary of recent literature on the subject was prepared by the Chairman and Dr. E. H. Nash, and formed an appendix to Mr. Waldram's paper. A series of queries on fundamental points connected with daylight illumination was also prepared and circulated among corresponding members of the Society, including various Continental authorities who had made the natural lighting of schools the subject of lifelong study. These queries, and the replies received, were subsequently published in the official Journal of the Society.†

In this way much useful information was obtained and the views of a number of experts were placed side by side. It soon became evident that while there was fair agreement on certain points, there were wide differences of opinion on many others. There were also cases in which it was frankly confessed that the necessary information, on which to base an opinion, was not available.

In view of the admitted importance of good daylight illumination in the schools of this country (in the schools of London alone there are over one million children), it seems desirable that the study of the subject should be taken up in a more systematic manner. Much of the information sought would be of value in other directions, for example, as bearing on the admission of daylight into workshops and factories. It must be remembered that by far the greater portion of the work of the world is still carried out by daylight, and that our conceptions as to what is necessary and desirable by artificial light are moulded to a great

* ILLUM. ENG. Lond. July 1913, p. 364.

* ILLUM. ENG. Lond. Jan. and Feb. 1913.

† ILLUM. ENG. Lond. Jan. 1914, pp. 33–43.

extent by our experiences during the day; the study of daylight illumination has therefore a direct interest even to those who are primarily concerned with artificial illumination.

In preparing this Interim Report the chief aim of the Committee has been to summarise the results of several main lines of investigation having for their object the setting up of a standard of daylight illumination in schoolrooms; and to make a few tentative recommendations as to how these principles may best be carried out in practice.

It is also hoped that the Report will be instrumental in drawing attention to some of the gaps in our knowledge of daylight illumination and suggesting fruitful lines of further investigation.

It is convenient to draw a distinction between Fundamental Principles affecting the provision of adequate illumination in schoolrooms, and Practical Applications, by which is understood the carrying out of these principles in actual practice.

These two aspects of the subject will be dealt with in turn.

Fundamental Principles.

These separate naturally into two groups:—

Physical, concerning light, climate, the building and its environment.

Physiological, concerning the visual apparatus of the workers and the subjective impression received.

Both of these groups include extremely variable quantities which are difficult to express in numerical terms, except in the form of averages deduced from a large number of measurements.

Sky-brightness, the most important physical quantity concerned, varies within very wide limits according to the time of the year and day, and even the estimated value at a certain hour on a certain day may vary enormously from the average value in the course of a few minutes. The absence of complete data showing the variation in the intensity of daylight in foot-candles according to the time of the year and day in this country (similar to those determined during a series of years for the State schools in Kiel by Prof. L. Weber), hinders considerably the investigation of daylight illumination. The Committee consider that it would be highly desirable for a series of researches of this kind to be undertaken. In view of the variation in the conditions met with respectively in smoky cities and in the country, it would be desirable for tests to be made simultaneously at several different stations, and they should also be extended over a number of years.*

Sky-brightness, however, as a physical magnitude is capable of accurate definition and measurement.

The illumination directly due to the sky at a point on a horizontal plane within a room depends on:—

The amount of sky visible from that point.

The brightness of this area of sky.

Its angular elevation.

If the lighting is effected by vertical windows the solid angle subtended by the visible sky at any working position in the plane of reference is usually small enough for the illumination there to be given by the formula:—

$$B \omega \sin \theta$$

where B is the brightness of the visible sky expressed in candles per square foot, ω is the solid angle in question, and θ its average angle of elevation. As $\sin \theta$ is a quantity increasing with θ, the value of "high angle light" is demonstrated.†

It is sometimes convenient to express the sky-brightness in terms of foot-candles (on the so-called secondary system used in the researches of Weber and others). If e denote the brightness

* No complete systematic series of photometric tests of the unrestricted daylight illumination in foot-candles has yet been made in this country on the desired scale, but daily records of the sun and sky radiation have been taken by the Royal Meteorological Laboratory at South Kensington with a Callendar radiomicrometer. It is possible that a careful comparison of these tests with those carried out on a photometric basis might enable some useful conclusions to be drawn from past records.

† If the solid angle is expressed in "square degrees," then the above product is the sky-area expressed in "reduced square degrees" as used by Weber and Cohn.

The nature of the square degree was explained by Prof. S. P. Thompson in a note on the Measurement of Solid Angles (ILLUM. ENG., January 1912, p. 15). See also note in Appendix.

There are approximately 41,250 square degrees on the surface of the sphere.

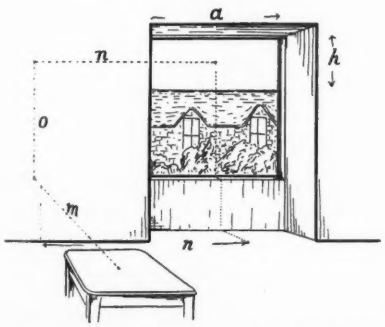
in foot-candles,* then the above formula becomes :—

$$\frac{e}{\pi} \times \omega \times \sin\theta$$

One advantage of expressing the sky-brightness in this way is that the illumination on a horizontal surface due to a uniform sky of indefinite extent parallel (the "unrestricted daylight illumination") becomes equal to the brightness of the sky itself. When the brightness of the sky is estimated by comparison with the illuminated surface within a photometer it is also conveniently measured in foot-candles.

Pleier (*Zeit. f. Schulges*, 1909, p. 461) has worked out a simple formula for obtaining the reduced square degrees of uninterrupted sky visible from a desk. If m is the perpendicular distance of the desk from the window wall, n its horizontal distance in the plane of this wall from the point on the window corresponding to the centre of visible sky, o the vertical height of this point above the desk, a the average horizontal, and h the average vertical width of the portion of window corresponding to sky visible from desk, then $R=\omega \sin\theta$

$$=3283\frac{a.h.m.o.}{(m^2+n^2+o^2)^2}$$



By the aid of this formula and a knowledge of the average variation in daylight illumination throughout the day and year, it should be possible to calculate with fair exactitude the average direct illumination at any point in a given building. This has been proposed by Weber as an aid in school planning. In addition to the value so obtained there would be a certain extra illumination due to reflection from the walls and ceilings of a room. It is possible that in schoolrooms of standard dimensions allowance for this might be made by using a suitable factor provided the nature of the walls and ceilings were known. But a considerable number of additional experiments seem necessary to establish this point.

It has also been suggested that the illumination in a room might be predicted by means of experiments with small models, either carried out in daylight or with some form of artificial sky. Some experiments carried out by members of the Committee on this point gave promising results, but here again more exhaustive experiments are needed. From inquiries instituted among Continental authorities it would appear that few have had experience of this method, but the subject is one that would repay further investigation.

The Committee have considered the question of a standard of daylight illumination in schools. The extreme variability of daylight renders an actual measurement of illumination at any particular spot of little service as a standard. On the other hand, the ratio between the unrestricted illumination out of doors and the illumination at a certain point in a schoolroom should be a very constant quantity, dependent on the nature of the building but independent of climatic conditions within wide limits. Such a ratio might serve as the basis for rules for the attainment of adequate lighting.

Prof. L. Weber has suggested that in an adequately-lighted schoolroom the illumination on the worst-lighted desk should not be less than 0·5 per cent. of the so-called "unrestricted illumination" from a complete hemisphere of sky, and a similar conclusion was reached independently by Mr. P. J. Waldram in this country.* The measurements so far carried out by the Committee suggest that this value is attainable in a well-designed schoolroom.

* When a luminous surface is said to have a surface-brightness of so many foot-candles this means that its brightness is the same as that of a dead white surface with a reflecting power of 100 per cent. which receives the illumination of this value.

* A Standard of Daylight Illumination in Interiors, ILLUM. ENG. Lond. Vol. II., 1909, p. 469.

The simplest and most accurate method of determining this ratio would doubtless be to measure simultaneously the illumination on the worst-lighted desk and the unrestricted daylight illumination as received on a horizontal plane exposed to a complete hemisphere of sky. But in practice it is frequently difficult to find a spot from which the complete sky is visible, and in the experiments undertaken by the Committee it was found more convenient to obtain the "sill ratio," *i.e.*, the ratio between the illumination on the worst-lighted desk and the illumination from a quadrant of sky received on a horizontal surface on the window sill. This value will be affected to some extent by the obstruction of neighbouring buildings. But in the case of modern schools, owing to the space usually allotted to playgrounds, a practically uninterrupted view of the sky should generally be available, and the error so caused will be small. The experiments so far conducted indicate that on the worst desk in well-designed schoolrooms the sill ratio should not be less than 1 : 100. This result is in substantial agreement with the suggestion of Weber referred to above, and might be put forward as a tentative standard, pending further investigations.

A school place which required artificial light between 9 a.m. and 4.30 p.m. in normal weather, between March and September, is obviously unfit for use. On the other hand, a school place enjoying a "sill ratio" of 1 : 100 should only require artificial light towards the end of the school day in winter.

The daylight ratio may also be determined by methods involving direct observation of the brightness of the sky. In circumstances where it is only possible to obtain a view of a small portion of the sky this method may be used, and may give useful results when the sky is uniformly bright; but in view of the difficulties introduced when skies of very variable brightness are met with, the methods proposed above seem preferable in connection with school buildings.

Physiological factors vary greatly with individuals, and while exceedingly important, their influence is also difficult to assess.

There is little doubt that the eye may suffer congestion and strain owing to imperfect illumination. This may lead to actual damage, and is probably an important factor in leading to the development of myopia (short sightedness) in the case of individuals so disposed. Poor light causes excessive efforts of the external muscles of the eye to converge the visual axis on the subjects looked at, and also a still more fatiguing effort in many children for the accommodation of the lenses, so as to obtain from a poor light as clear and defined an image as possible. In such a case the head and eyes are generally brought near the object, thus aggravating all the muscular strains. This is a habit which it is of special importance to avoid in school work. There is much less need for such excessive effort when the light is sufficient to give the mental picture without strained attention.

In judging the illumination required it is necessary to bear in mind the physiological variations referred to above. It must always be remembered that about 10 per cent. of elementary school children are subnormal to the extent of having only one-third the usual visual acuity, so that any latitude in estimates should fall on the side of excess of light.

But there is another factor which affects the average amount of daylight required for a school desk—the adaptation of the retina. Where the average illumination remains fairly constant, as in artificial lighting, adaptation is not a factor of prime importance, and the problem of determining the amount of illumination for reading and writing is less complicated. But in the case of daylight illumination, where a considerable section of the visual field may have a brightness hundreds of times that of the printed page or the surface of the blackboard, adaptation plays an important part.

The impression formed as to the sufficiency of daylight in a room is also influenced by psychical effects. Visibility depends on contrasts in colour and shadow. Subjective feelings of deficiency of light which arise in cases where there is not the usual brightness of surrounding surfaces, even though the desk illumination is ample, need consideration. Such feelings may be produced by rooms

lighted from the roof without side windows, or rooms with exceptionally dark walls.

For these reasons it is difficult to prescribe the absolute value of the illumination in the same way as by artificial light. Mr. N. Bishop Harman has advocated a standard of 9 foot-candles.* It is, however, possible to read with a considerably lower illumination, but in other circumstances a value of illumination much higher than this may appear necessary. For example, on a dull day it has been found possible to work comfortably with 5 foot-candles and to see to read with only half a foot-candle, but on a bright day 8 foot-candles, in a shaded corner, seemed insufficient. In cases where playground sheds judged by eyes with daylight adaptation had been complained of as insufficiently lighted, photometric readings of 15 to 25 foot-candles were noted. To investigate completely the effect of adaptation in connection with ordinary daylight illumination would be a valuable piece of work, but was obviously too intricate a problem to be undertaken in detail by the Committee.

During most of the school hours a place sufficiently lighted for school work will probably yield photometric readings of at least 5 to 10 foot-candles. In such rooms during unusually dark weather or in the later hours of the day, the increased sensitiveness of the eye will compensate for decreased illumination. When this illumination on the worst-lighted desk falls to 2 foot-candles, the standard recommended for artificial lighting, the daylight should be excluded and artificial light used.† It may be recalled that Cohn considered a room sufficiently lighted by day if the worst-lighted place received about $2\frac{1}{2}$ foot-candles illumination.*

Weber found that with the average value of the sky-brightness likely to be met during the hours of study, this illumination should be obtained on any desk receiving 0·5 per cent. of the unrestricted daylight illumination out of doors.

It is likewise advocated by Cohn as being consistent with his recommendation that at the worst-lighted place in a schoolroom 50 square degrees of sky should be visible. There is thus some ground for suggesting that the 2 foot-candles, as recommended in the recent report on The Artificial Lighting of Schools, should also be regarded as a tentative standard for the minimum readings permissible for illumination by daylight.

But it seems preferable to adopt one of the methods which largely eliminates the variation in adaptation of the eye by specifying in general terms the conditions enabling a certain access of daylight to be obtained—and hence an adequate illumination with an average brightness of sky—rather than to attempt to specify an absolute value of illumination in the room.†

Another physiological factor to be kept in mind is the glare from excess of sunlight. In England this is not of very great importance, as it can readily be avoided by the use of light blinds and curtains. West rooms sometimes cause trouble owing to the low incident rays from the setting sun. Most horizontal beams of light, as, for instance, those from shiny walls or badly arranged prismatic glass or mirror reflectors, may cause glare, and therefore intense light from this direction should preferably be avoided.

Practical Applications.

It has been remarked that the construction of the most modern schoolrooms, favourably situated as regards

* Brit. Med. Assn. 1911; "School Hygiene," 1912, p. 24.

† Reference may be made to a suggestion made in the course of the discussion of Mr. Waldram's paper before the Illuminating Engineering Society on December 16th, 1913, that an apparatus should be designed to indicate automatically when the daylight illumination in a room had fallen below a prescribed value and artificial light was necessary. A trustworthy instrument of this kind would seem to have important applications in schoolrooms and factories.

* The actual figure given was 50 Metre-Kerzen measured with a red screen. This would be equivalent to about 25 M.K. measured photometrically in the ordinary way, *i.e.*, approximately $2\frac{1}{2}$ foot-candles.

† A rough test of sufficiency of lighting is provided by the readings of certain varieties of type. For example, if diamond type can be read easily at 20 inches, the light is regarded as sufficient; this is confirmed if the letters can be deciphered when looked at through a smoked glass which absorbs 96 per cent. of the light.

The above paragraph is in Diamond Type.

obstruction from neighbouring buildings, enables them to comply with the fundamental requirement that the worst-lighted desk should receive not less than 0·5 per cent. of the unrestricted daylight illumination out of doors. The other recommendation, that the illumination on the worst-lighted desk should be at least as great as the illumination derived from 50 square degrees of sky, leads to very similar results. For example, in general modern practice it is found that if the angular elevation of the top of the window-glass from any desk is not less than 27° and a strip of sky not less than 4° vertical opening is visible, the solid angle will almost certainly exceed 50 square degrees in value. This angle of elevation of 27° for the top of the window-glass implies that no part of any desk should be further from the window than twice the height of the window-top above the desk.

It will be observed that the rules of the Board of Education specify that "in the absence of a supplementary light the measurement from the window-wall in a room 14 feet high should not exceed 24 feet 8 inches." With these dimensions the angle made with the top of the window glass is not far removed from the value suggested above.

The Committee have found the Building Regulations (1907) of the Board of Education (see Appendix I.) to be generally productive of good results. It would appear, however, that the words "top of glass in windows" should be substituted for "top of windows," so as to stipulate that the top of glass should be at least the same relative height in deeper or shallower rooms. There also appears to be no serious structural reason why windows in classrooms should not be flush with the ceiling. In view of the desirability of securing a strong light on the ceiling, and utilising to the full the efficient upper portion of the window, this is recommended. Any diminution in glass area with a view to conserving heat should be made at the *bottom*, provided that the raising of the sill does not detrimentally affect the lighting of the desks adjacent to the window wall.

Experience shows that the area of window glass should not be less than one-fifth of the floor space in rooms up to 20 feet across, and one-quarter of the floor area in wider rooms. The window should be square-topped and its effective area should not be diminished by ornamentation, pillars, ledges, or cornices, but all edges should be bevelled off. The obscuring of glass in windows, and neglect to keep them properly clean, are frequently responsible for a considerable loss of light.

As the lighting of a many-storied school with surrounding buildings will be worst in the lower floors the ground floor should be used for offices, cloakrooms, bathrooms, dining halls, &c. It would be advantageous to increase the height of the windows in the lowest schoolrooms, reducing the height of the top floors if necessary. In the lowest rooms the smallest desks should be used, as every increase in the height of desks means an equivalent potential decrease in height of window top. At the same time most light is needed in the infant classrooms (which are usually placed on the lower floors of school buildings) and where the smallest furniture can be used.

There is now a consensus of opinion that the lighting of classrooms should be from the wall on the left-hand side of the children. Right-handed lighting is to be deprecated as causing confusing shadows. In general bilateral lighting is less satisfactory than left-lighting, although in some special circumstances it may be permissible.

Lighting from behind the teacher is usually a source of glare to the children who face the window. Similarly, lighting from behind the children is apt to cause glare and discomfort to the teacher. It is also educationally disadvantageous in that the children's faces, being seen against a bright background, are not well defined. Moreover, back-lighting is apt to cause shadows of the children to fall on their work, and may lead them to assume unnatural and harmful positions.

Roof lighting generally provides an abundant light, but, unless used with discretion, gives a comfortless impression. It is useful in workshops, carpentry, and manual training centres, and is often desirable as a secondary means of lighting. Skylights, which are apt to leak, are to be distinguished from lantern lights and dormers, which, besides being very useful

in mitigating defects in lighting, are often also useful as a means of ventilation.

Where a window, as an aid to cross draught ventilation, is located in other than the main lighting walls, it should be high, and it would perhaps be an advantage to have its light reflected to the ceiling. Borrowed lights are particularly ineffective. The fraction of light passing is in general of small value, and the loss of reflection from the wall area replaced by glass may be considerable. Glass partitions in the wall of a classroom tend to transmit noise from adjacent rooms and also have a distracting effect, causing the attention of children to wander.

The sloping of floors, and the raising of back desks to give children occupying them a better view of the blackboard, should be condemned if leading to loss of valuable high angle light. The Committee have also considered the desirability of slewing desks slightly, so as to enable a book or paper held vertically to receive a better illumination. It appeared that a material increase in light could be obtained in this way, but the advantage was only sufficient to justify the consequent curtailment of gangway space in extreme cases.

The internal decoration of a schoolroom should be arranged with a view to good diffusion of light. The ceiling and a frieze of 2 feet should preferably be white. The walls behind the children and opposite the windows should be light-tinted from at most 30 inches above the desk level; below this level the walls might with advantage be somewhat darker. The practice of covering the walls with white diagrams on black material may interfere with the reflection of light from the walls. From this standpoint diagrams on a white background are preferable. The wall surrounding and behind the teacher's blackboard should not be too light. The desks and furniture should all be finished a comparatively light colour (grey or dove colour is very suitable), and dark colours or black should be avoided.

These suggestions might be summarised as follows :—

No place is fit for use in a schoolroom when diamond type cannot be read easily by a normal observer at a distance of half a metre (20 inches).

This is Diamond Type.

The darkest desk in any schoolroom should receive an illumination equivalent to that derived directly from 50 reduced square degrees of visible sky. In these circumstances the place should receive not less than 0·5 per cent. of the unrestricted illumination from the complete sky hemisphere.

The windows should be located in the wall to the left of the pupils, and the glass should be carried to the ceiling and not interrupted by cornices, pillars, or decorations.

No desk in a schoolroom should be farther from the window wall than twice the height of the top of the glass above the desk surface.

The ceiling should be white. The wall opposite to the window and the wall behind the children should be lightly coloured from 30 inches above the desk level. The wall around or behind blackboards should be somewhat darker than the rest of the room.

All furniture, desks, and surfaces in the lower part of the room should be finished in an unobtrusive colour, dark shades and black being avoided.

Conclusion.

The Committee would like to make it clear that the suggestions in this Report are tentative, and that there are many fundamental points affecting the admission of daylight into buildings on which further information is desired to put the subject on a scientific basis.

Reference has been made to several lines of investigation which require to be carried out on a scale beyond the resources of the Committee to yield satisfactory results. The following are a few suggested lines of investigation :—

(1) *Tests to be undertaken showing the average variation of daylight during the day, and throughout the year. These tests should cover a number of years and should be undertaken simultaneously at various centres so that the results can be compared and allowance made for difference in local climatic conditions. Possibly study of the*

records of radiation prepared by the Meteorological Office by physical methods might furnish useful information on the conditions in past years.

(2) *Further tests of natural and artificial illumination under varied conditions should be carried out in schools, and correlated with tests of the eyesight and general physique of school children in order to trace the circumstances which give rise to defective sight.*

(3) *An investigation of the minimum daylight illumination necessary for various kinds of school work (reading, writing, needlework, manual work, &c.), bearing in mind the part played by adaptation of the eye. This might be useful for determining the minimum value of daylight, which is in general necessary in order to avoid conditions which are economically and hygienically prejudicial.*

(4) *Confirmatory data are needed with regard to the tentative standard of access of daylight into buildings (i.e., that the illumination in a room should be equal to at least 0·5 per cent. of the unrestricted full daylight illumination) in order to ascertain* (A) *how far this standard is practicable in the case of new buildings;* (B) *what percentage of existing buildings satisfy this condition;* (C) *how far external obstructions interfere with it.*

(5) *Records of the illumination should be made in all newly erected schools, particularly those having novel structural features, and would help to trace the influence of such departures in design.*

(7) *The existing regulations relating to the permissible distance apart of buildings, width of streets, &c., required for town planning should be considered in the light of the access of daylight into buildings, and if possible some agreement as to the degree of permissible obstruction arrived at.*

(6) *The value of photometric tests with small models needs further investigation, as they may offer means of predetermining the daylight illumination in interiors, and of testing the effect of windows of varied size and position, and the influence of materials of various reflection coefficients for the walls and ceilings, &c.*

These inquiries would be of value in connection with school buildings, and many of them would have an important application to buildings in general. But it is clear that a comprehensive series of experiments on such lines is beyond the unaided resources of the Committee. The Committee, therefore, ventures the hope that a fuller investigation into some of these debatable points will receive the support of the Educational Authorities and of other institutions whose co-operation with the Illuminating Engineering Society would aid in the solution of these problems.

By order of the Council,

LEON GASTER
(*Hon. Secretary*).

APPENDIX I.

LEGISLATION AND BYE-LAWS RELATING TO WINDOWS.

Rules affecting the size of windows appear in some of the private Acts of Parliament of Cities and Boroughs, and in some of the Bye-Laws approved by the Local Government Board for Urban and Rural Districts.

There is no legal necessity for such rules to be identical, but the provisions embodied in the London Building Act of 1894 may be cited as examples.

Section 54 (1) stipulates that openings above the ground storey in external walls shall not exceed half the superficial area of the walls.

Schools generally have to be built to comply with the Local Building Act or Bye-Laws, and this clause is obviously intended to minimise the risk of spread of fire between buildings which are as close together as they can legally be built in crowded situations. Schools and similar buildings requiring ample light are never close together in crowded situations, and it is most desirable that statutory provision should be made exempting them from such clauses in all cases of external walls which are at least say 20 feet from the nearest building, and of which the structural stability is sufficiently provided for.

Section 70 (1) c stipulates that habitable rooms shall have vertical windows, which shall be at least one-tenth of the floor area with a head at least 7 feet above the floor or dormer windows, one-twelfth of the floor area with a head at least 5 feet above the floor or lantern lights, of which a portion equal to one-twentieth of the floor area can be opened.

These are minimal requirements, which afford no criterion as to what is necessary for schools. The significant absence of any stipulated minimum size of lantern

or roof lights supports the general consensus of opinion as to the superiority of light coming from a high angle.

The Building Regulations of the Board of Education (1907) relating to the windows of new buildings for Public Elementary Schools are as follows :—

" *Part I., Section* 5 (*b*).

A classroom should not be planned to accommodate more than from 50 to 60 children, but in special cases somewhat larger rooms may be approved. In the absence of supplementary light the measurement from the window-wall in a room 14 feet high should not exceed 24 feet 8 inches. Except in very small schools, classrooms should not be planned for less than 24 scholars.

Part II., Rule 6—*Lighting.*

Every part and corner of a school should be well lighted. The light should, as far as possible, and especially in classrooms, be admitted from the left side of the scholars. (This rule will be found greatly to influence the planning.) All other windows in classrooms should be regarded as supplementary or for ventilation. Where left light is impossible, right is next best. Windows full in the eyes of the scholars cannot be approved. Unless the top of the windows be more than 14 feet above the floor, the plan should show no space more than 24 feet from the window-wall in any room used for teaching.

(A) Windows should never be provided for the sake merely of external effect. All kinds of glazing which diminish the light and are troublesome to keep clean and in repair must be avoided. A large portion of each window should be made to open for ventilation and for cleaning.

(B) The sills of the main lighting windows should be placed not more than 4 feet above the floor, the tops of the windows should as a rule reach nearly to the ceiling, the upper portion should be made to swing. The ordinary rules respecting hospitals should here be remembered. Large spaces between the window heads and ceiling are productive of foul rooms.

(C) Skylights are objectionable. They cannot be approved in schoolrooms or classrooms. They will only be allowed in central halls having ridge or apex ventilation.

(D) The colouring of the walls and ceiling and of all fittings in the rooms should be carefully considered as affecting the light. This point and the size and position of the windows are especially important in their bearing on the eyesight of the children.

(E) The windows should be properly distributed over the walls of the classrooms so that every desk shall be sufficiently lighted. The glass line of the window furthest from the teacher should be on a line with the back of the last row of desks.

Rule 7 (*a*)—*Ventilation.*

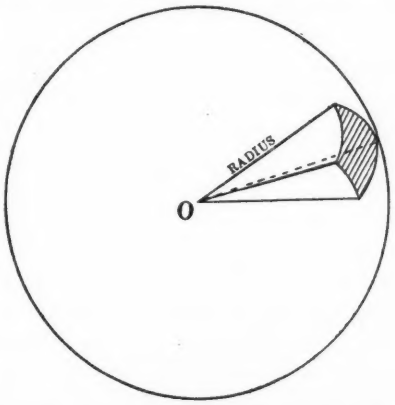
Although lighting from the left hand is considered so important, ventilation demands also the provision of a swing window as far from the lighting as possible and near the ceiling."

APPENDIX II.

THE MEASUREMENT OF SOLID ANGLES.

As the solid angle plays such an important part in daylight calculations, it may be well to add a few notes on the measurement of such angles, and their use in photometry. This matter has been dealt with in an article in THE ILLUMINATING ENGINEER for January 1912, by Prof. Silvanus P. Thompson.

Solid angles are measured in terms of the area subtended at the point of measurement divided by the square of the distance. The amount of solid angle which at unit distance radius is subtended by unit area is known as " one steradian "



(or " sterean "), and the above formula makes use of solid angles expressed in terms of this unit. The whole solid angle of space around any point will be 4π steradians. A window 6 feet high and 3 feet wide at a distance of 30 feet subtends approximately

$$\frac{6\times 3}{(30)^2} = \frac{1}{50} \text{ steradian.}$$

There is another method of measuring solid angles which is sometimes con-

venient and has been widely adopted by Continental authorities in researches on school lighting, namely, "square degrees."

A "square degree" is equal to the solid angle subtended by a square each of whose sides subtends one angular degree. Now on a sphere of unit radius the length of 1 degree is obviously $\pi/180$. Hence the area of one square degree mapped out on the surface of such a sphere will be $(\frac{\pi}{180})^2 = 0{\cdot}0003046$ units of area; therefore one square degree is equal to 0·0003046 steradians.

"Fifty square degrees" (Cohn's value which occurs frequently in the foregoing report) is equal to about 0·015 steradian. Assuming the most remote place in a schoolroom to be 24 feet from the window, it is necessary for rather less than 9 square feet of window-space to be occupied by unobstructed sky, in order to yield the 50 square degrees required.

For $\frac{9}{(24)^2} = 0{\cdot}0156$ steradians (which is more than 50 square degrees).

If a place in a schoolroom receives light from a certain area of sky, a, having a brightness B candles per sq. ft., and at a distance d, the illumination on the desk will be :—

$$B \frac{a}{d^2} \sin \theta$$

if θ is the average angle of elevation.

Naturally d, the distance of the sky, cannot be determined. But a/d^2 is the solid angle ω subtended by the sky at the place in question, and the formula therefore becomes :—

$$B \omega \sin \theta.$$

[It is proposed to reprint this Report, together with the Appendix to Mr. Waldram's recent paper summarising Continental Research, and the corresponding Interim Report on the Artificial Lighting of Schools issued last year. This will form a synopsis of recent recommendations on School Lighting which, it is hoped, will be of special interest to architects, school medical officers, and others interested in this subject. Copies will be available at a cost of 6d. each.]

THE CAUSE OF FATIGUE.

In the *Zeitschrift für Beleuchtungswesen* reference is made to the researches of Professor Roth, of Potsdam, on fatigue. The Professor points out that in every occupation there are special varieties of fatigue arising from the calls which they make on the workman's frame and vitality. Fatigue may occur in certain organs, the muscles and the nerves. It is the natural consequence of over-exertion.

In the case of artisans, muscular fatigue plays a considerable part as certain muscles are overworked; again, trouble may arise through cramped attitudes, which interfere with breathing or circulation of the blood. Fatigue shows itself in deeper breathing, acceleration of the pulse, rising of temperature, and diminution in efficiency. Rest is the most potent method of guarding against the consequences of fatigue. A certain time is necessary for the body to recover, and it would be well if employers recognised the importance of providing a sufficiently lengthy interval of rest during the day. A stop in the middle of the day is particularly desirable.

Other special defects, such as flat feet, cramped fingers, and night-blindness or trembling of the eyelids, may be caused by certain occupations.

It is probable that in some industries defects of eyesight are caused by deficient illumination, but in any case the inconvenience to which bad lighting gives rise is apt to impose nervous strain and so cause fatigue.

SHORT NOTES ON ILLUMINATING ENGINEERING.

INSUFFICIENT ILLUMINATION AS A CAUSE OF NYSTAGMUS.

Mr. McKenna stated in the House of Commons last week that researches made in recent years appeared to point strongly to the conclusion that working in insufficient light was the main cause of miners' nystagmus, and this point was kept in view when it was decided to impose photometric tests for all types of safety lamps approved under the Coal Mines Act 1911. He was advised that as a result of these tests, and of the increasing use of electric lamps, the illumination below ground was improving, and he trusted that as this improvement continued it would have a substantial effect in reducing the number of cases of nystagmus.—*Elec. Rev.*

LAMP TO INDICATE THE CENTRE OF THE UNITED STATES.

According to *L'Electricien* a novel method has been used to indicate the exact centre of the United States, which is located at Bloomington, in Indiana. A pedestal has been erected which carries a mast and flag, and the latter is illuminated by means of a 120 candle-power lamp.

AN ANCIENT LIGHT CASE.

The *Builder* contains an account of an action concluded before Mr. Justice Lawrence in the King's Bench Division on Thursday, April 23rd, in which Alderman J. C. Tozer, an ex-Mayor of Devonport and the owner of a large drapery business, was sued for the obstruction of Ancient Lights. In the course of the proceedings Mr. Justice Lawrence personally viewed the premises. He pointed out that it was not enough merely to show that the light had been diminished; it was also necessary to prove that the efficiency of the workshop had suffered. In one of the rooms it was difficult to say there was such an injury, but in the lower workshops the diminution of light led to a diminution in the capacity for work; for this compensation to the value of £150 was awarded.

This is an interesting judgment. But there must be many cases in which it is difficult to say exactly whether injury has been caused and to what extent the illumination can be diminished without the work suffering. Would it not be possible to establish a definite minimum value of illumination which ought always to be exceeded in premises where people habitually work by daylight?

TRAFALGAR SQUARE BY NIGHT.

The illustration, showing a night view of Trafalgar Square, brings out very clearly the "silhouette-effect" which is very frequently met with in outdoor lighting. We see objects, not by the light reflected from them, but as dark objects silhouetted against a bright background. The picture also shows how relatively dark the central portion of the square is compared with the lights round the edges—a point which has often been commented upon by visitors to London.

Trafalgar Square by night.

RESPONSIBILITY FOR ELECTRIC LIGHT INSTALLATION.

Much attention has been devoted in the technical papers to the case of the Secretary of State for War *versus* Messrs. Kirkland & Capper and Mr. J. H. T. Woodd with reference to the electric lighting of the new Army Medical College at Millbank. The electric wiring was unsatisfactory and the Architect was sued for negligence. His defence was that, as the Architect, he was not responsible, and that the contract provided for the electric lighting to be placed in the hands of experts.

In the end judgment was entered for the plaintiff. It appears that this is one of the many cases in which the client falls between two stools. The lighting is not taken up sufficiently seriously either by the Architect or the Contractor engaged, and the result is defective work. We have frequently pointed out that in the case of a large building it would be well worth while to have a special expert to have control of the lighting arrangements, and to make him solely responsible.

A JOINT STREET LIGHTING COMMITTEE IN THE UNITED STATES.

We are interested to note that a Street Lighting Committee has been formed in the United States under the auspices of the National Electric Light Association and the Association of Edison Illuminating Companies.

The movement in favour of a standard specification on street lighting, which has been so actively taken up in this country, is evidently being developed in the United States. We understand that the Committee will have the assistance of a number of gentlemen prominently associated with street lighting, and the results of their investigations will be followed with much interest in this country. We believe that it is proposed to conduct the investigations on a very large scale, and that practical experiments on street lighting installations will fill an important place in the programme.

NELA RESEARCH LABORATORY

(CLEVELAND, OHIO, U.S.A.).

We have frequently called attention to the important work carried on in the Nela Research Laboratory (Ohio, U.S.A.) under the supervision of Dr. E. P. Hyde. We now learn that an important departure has been made in the establishment of a Section of Applied Science, which is supplementary to the department of Pure Science established about five years ago. We feel sure that this departure will add considerably to the reputation of the Laboratory, and we shall look forward to the publication of its work with great interest.

We are also informed that Dr. C. E. Mendenhall, Prof. of Physics at the University of Wisconsin, Dr. Knight Dunlop, Associate Professor of Psychology at the Johns Hopkins University, and Dr. W. E. Burge, Assistant Professor in Physiology at the University of Illinois, have accepted invitations to carry on research at the Nela Laboratory during the summer. Dr. Willibald Weniger, of the Oregon Agricultural College, and Mr. A. F. Wagner, of Purdue University, are also to take part in the work.

Finally we note that a research fellowship in Ophthalmology has been established for the year 1914-1915, with an honorarium of 700 dollars, with a view to the carrying on of researches on the effects of light and radiation on the eye.

THOMAS NEWBIGGING.

IT is with great regret that we record the death of Mr. Thomas Newbigging in his eighty-first year. Sir Thomas was widely known and honoured in the gas industry, not only for his attainments but for his charming personality.

He was associated with many historic events in the history of gas lighting. Entering the industry in 1857, he soon began to publish articles and to undertake educational work in addition to his ordinary duties, and his *Handbook*, which has since been re-edited many times, was one of the first treatises on gas engineering.

Fifty-one years ago he was instrumental in forming a small body of enthusiasts, which afterwards developed into the Institution of Gas Engineers, of which he was President and Hon. Treasurer.

Sir Thomas was indeed one of the "Grand Old Men" of the industry, and his loss will be widely regretted.

Born 1833—Died 1914.

REVIEW OF THE TECHNICAL PRESS.

[Owing to the pressure on our space we are somewhat reducing the length of this article: we shall include the various items omitted in next month's review.]

THE subject of **street lighting** is being keenly taken up in the United States, and it is stated that an influential Committee is being formed to carry out practical experiments. J. R. CRAVATH (*Elec. World*, May 9th) points out that preconceived ideas have been quite upset by the arrival of many new illuminants: many problems will have to be considered *de novo*. In most American streets, he says, objects are still seen mainly as "silhouettes" against a bright background, but this may be changed in the future.

Another piece of interesting news from the United States relates to the work of the newly formed "**Society for Electrical Development**," to which we refer elsewhere. (See p. 375.)

H. E. IVES (*Journ. of the Franklin Institute*, May) has a long article on **Artificial Daylight.** The various steps are described and some more information given on the application of the daylight screen to incandescent mantles. Those with 0·1 per cent. ceria give a much whiter light than when 0·5 per cent. ceria is used and are more efficient for conversion into artificial daylight. The author also describes the use of "artificial daylight spectacles," and enters into a calculation of the cost of producing artificially, in an average dwelling room, an exact reproduction of daylight conditions, both as regards colour and intensity. The room in which his experiments were made would require 20,000 watts; but *if* one could produce *only* the exact radiation wanted, 50 watts would suffice.

Another article in the same number of the *Journal of the Franklin Institute*, by C. O. HARRINGTON, deals with **Light Signals.** Diagrams of various lenticular arrangements, showing the distribution of candle-power, are given. There is also an article on a similar subject by WOLF (*Z.f.B.*, May 10th).

M. LUCKIESH (*Elec. World*, May 16th) has been carrying out some rather novel experiments with the **flicker photometer.** Among other points, he raises the question whether such instruments give the same results as those of the equality-of-brightness type; and whether the result, even if consistent, is physiologically correct. He compares a pure yellow light with a composite one, which is exactly similar to the eye, but is a mixture of red and green. Both types of instruments give substantially the same results in this comparison, which is evidence in favour of the correctness of the flicker photometer.

F. LAPORTE (*Bull. Soc. Int. des Electriciens*, April) describes briefly some tests on the **efficiency of cinematograph apparatus.** Tests on six different types of apparatus were made and very variable results obtained. For example, with the apparatus stationary, illumination on the screen varying from about 1—450 lux (approx. $\frac{1}{10}$—45 foot-candles) were recorded, and the useful flux on the screen was in one case as low as 1 lumen and in another as high as 1,400 lumens. The apparatus tested included arc projectors, and those using Nernst and miniature tungsten filaments. The

efficiency of the apparatus tested varied from 13—277 millilumens per watt according to how it was used.

Among other articles on photometry we may note the account of a lawsuit in the United States arising out of some **street lighting tests** (*Elec. World*, April 25th). The case was remarkable for the number of photometric experts called in evidence.

A considerable number of tests had been carried out, and a variety of photometric methods used, showing that the lamps *in situ* were not giving their rated candle-power. But the tests were set aside and judgment was given in favour of the contractor.

In *Licht und Lampe* (May 7th) there is a rather interesting article dealing with the **lighting of prisons,** and describing the special wiring arrangements needed in order to make it impossible for the prisoners to tamper with the lights.

LUX (*Z.f.B.*, May 10th) describes some of the chief methods of **theatre lighting.** The almost universal system now prevailing is to have banks of lamps in four colours, separately controlled through rheostats, so that any desired tint for the main illumination can be obtained. For special colour-effects arc lamps with treated carbons, or reflection from coloured surfaces, are also used.

Turning to articles on illuminants in general we may note Pausert's contribution (*Rev. Electrique*, March 20th) on the lighting of a section of Paris by the new **Bardon-Carbone arc lamps.** These lamps use mineralised carbons in an enclosed space. In the direct current lamps the electrodes last 110—120 hours, in the A.C. lamps about 90 hours. The watts per mean lower hemisph. c.p. are given for these lamps as 0·17 (D.C.) and 0·29 (A.C.) respectively.

Finally, reference may be made to some notes in a recent number of *Licht und Lampe* on the use of **special illuminants in warfare.** One of these is the magnesium bomb. This was originally intended to be thrown by the soldiers, and, bursting in the air, to shed a brilliant light, revealing the whereabouts of the enemy. But these missiles must be carefully directed, otherwise the glare they cause may be more troublesome to the party projecting them than to the enemy. Now it is found best to fire them a fair distance from a gun so as to get the light well above the army being attacked. Another special device is a chemical preparation which bursts into a brilliant flame when thrown on the water; this is considered useful to reveal the whereabouts of the enemy, when fording rivers, &c.

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Editorials. The Flicker Photometer (*Elec. World*, May 16th).
The Study of Street Lighting (*Elec. World*, May 9th).
Harrington, C. O. Light Signals (*Journ. of the Franklin Inst.*, May).
Ives, H. E. Artificial Daylight (*Journ. of the Franklin Inst.*, May).
Laporte, F. Essais Photometriques Sommaires d'Appareils Cinematographiques (*Soc. Int. des Electriciens Bull.*, April).
Luckiesh, M. Heterochromatic Photometry (*Elec. World*, May 16th).
Lux, H. Moderne Theater-Beleuchtung (*Z.f.B.*, May 10th).
Pausert, T. Les nouvelles lampes à arc de l'éclairage public à Paris (*La Revue Electrique*, March 20th).
Pfund, A. H. Laboratory Mercury Vapour Lamps (*Phys. Rev.*, April).
Schanz, F. Uber die Veränderungen und Schädigungen des Auges durch die nicht direkt sichtbaren Lichtstrahlen (*Z.f.B.*, May 10th).
Wolf, M. Neuere Beleuchtungsvorrichtungen für Leuchttürme oder dergleichen (*Z.f.B.*, May 10th).
Photometric Tests of Lamps for Street Lighting (*Elec. World*, April 25th).
Beleuchtung im Gefängnissen (*L.u.L.*, May 7th).
Neue Leuchtmittel für die Infantrie im Felde (*L.u.L.*, May 7th).
Activities of the Society for Electrical Development (*Elec. World*, May 16th).
Report of the Committee on Outdoor Lighting (*Am. Gaslight Jour.*, February 16th).

CONTRACTIONS USED.

Phys. Rev.—*Physical Review.*
L.u.L.—*Licht und Lampe.*
Z.f.B.—*Zeitschrift für Beleuchtungswesen.*

REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED.

Incandescent Electric Lamps and their Application. By D. H. Ogley. (*Longmans, Green and Co.* 2*s.* 6*d. net.* 1914; 107 *pp.*; 56 *illustrations.*)

IN this little book much that the author says is applicable to general illuminating engineering, although three out of the eleven chapters are devoted to incandescent lamps. The initial portion of the book deals with the chief photometric quantities and laws, the best known standards of light, and photometers. The treatment is necessarily condensed, and only one type of illumination-photometer is described. Following this we have the three chapters on incandescent lamps, an account of The Eye and the Principles of Vision, and a brief discussion on direct and indirect lighting. Finally there is a short account of illuminating engineering calculations.

The book contains a number of illustrations drawn from the American "primer" on "Light: its Use and Misuse," and others illustrating direct and indirect lighting. The latter appear to be drawn mainly from a few sources, and we think that in a second edition a somewhat greater variety might be desirable.

We are glad to see in the publication of this little book an illustration of the demand for literature on illuminating engineering, and we hope that the lecturers at other technical institutions will follow Mr. Ogley's example and take the subject up in their courses.

OTHER PUBLICATIONS RECEIVED.

A Handbook of Machine Shop Lighting.

We have received from the Industrial Commission of Wisconsin a booklet on Shop Lighting prepared by Mr. Schwarze, Electrical Engineer of the Pfister and Vogel Leather Company, Milwaukee. The State of Wisconsin has been exceptionally active in preparing recommendations on Industrial Lighting, and seems to have been one of the first authorities to take the matter up.

The book contains a number of illustrations of factory lighting by artificial light, and sketches of various types of reflectors suitable for local lighting. The recommendations are evidently the results of practical experience, and altogether it is an enterprising publication. There is just one point to which exception might be taken. The author habitually deals with the amount of illumination necessary by suggesting a certain number of candle-power per square foot. At this stage in Illuminating Engineering we think that it would have been preferable to have given this value direct in foot-candles.

Proceedings of the American Gas Institute, Parts I. and II., 1914.

As usual, these two volumes contain a record of a considerable amount of work. We note there are several communications dealing with illumination, including those of M. Luckiesh, C. A. Luther, and P. S. Millar.

Report of the Proceedings at the Third International Road Congress held in London, 1913.

This Report contains a record of some keen and useful discussions. Our only criticism is that the remarks of speakers have been reported verbatim; in some cases are discursive and not very intelligible, and would have benefited by a little closer editing.

THE SOCIETY FOR ELECTRICAL DEVELOPMENT.

A NEW MOVEMENT IN THE UNITED STATES.

IN a delightfully printed book which we have just received from the National Lamp Works of the General Electric Co. (Cleveland, Ohio, U.S.A.), the objects of this newly formed society are outlined. Under the heading of "Camp Co-operation" it summarises the various addresses of prominent members of the electrical industry delivered at Association Island in 1913, and is concluded by an account of the Society's Aims and Objects and By-Laws.

Its motto is "Do it Electrically." We have nothing similar in this country. The support of all the best known electrical engineers and of all the chief electrical organisations has been secured, and the Society is planned to include practically all concerned in the electrical industry.

The book mentioned above contains a series of 21 addresses, most of them bearing on co-operation. Mr. R. J. Crouse and Mr. H. L. Doherty describe and explain the aims of the Society, Mr. N. Macbeth deals with the co-operative features of the American Illuminating Engineering Society, Dr. C. P. Steinmetz deals with technical developments of the electrical industry, and there are contributions by Mr. J. B. McCall, Mr. A. W. Burchard, and others.

In a recent number of the *Electrical World* there is a more detailed account of its programme of this American Society, as set forth at the annual meeting held in Philadelphia on June 1st.

At the formation of the Society it was announced that 200,000 dollars would be necessary before a start was made. It appears that all details of organisation have been settled, and that the Society is now actively at work. Its programme is far-reaching. Local leagues are to be organised, and information and assistance for local displays and advertising will be obtainable from headquarters. Delegates will be present, and papers presented at all conventions where users of electricity assemble. Assistance will be given to builders, architects, and engineers in the preparation of proper specifications. The Society will co-operate with publishers of text-books in order that they may be kept up to date; moving picture films, showing the applications of electricity, will be furnished to schools; visits may even be arranged to neighbouring large works.

An attempt is to be made to collect information as to all possible uses of electricity in a variety of industries, and all this information will be tabulated at the Commercial Exchange Bureau at headquarters. Advice will be given on advertising, special writers will be engaged to write and prepare not only technical and popular articles, but even short stories, in which the uses of electricity will be introduced; and discussions on these subjects will be constantly organised at meetings of such bodies as the Electrical Contractors Association, the Electrical Supply Jobbers Association, and the National Electric Light Association.

Altogether the work contemplated is on a gigantic scale, and we shall be interested to see how this movement proceeds.

DR. A. S. McALLISTER.

WE note that Dr. A. S. McAllister has been elected President of the Illuminating Engineering Society (U.S.A.) for the coming session. Dr. McAllister was born at Covington, Virginia, in 1875. After passing through the Pennsylvania State College, he devoted himself to electrical engineering in connection with coal mining, and afterwards entered the works of the Westinghouse Company. Subsequently he entered on a post graduate course at Cornell University. For some years he was on the staff of the Pennsylvania State College, at which he is now the Professor of Electrical Engineering.

Dr. McAllister is also widely known as the Editor of the *Electrical World*. Although he has published works on electrical machinery and other branches of electrical engineering, he is well known as an expert on illumination, and has been an active member of several committees of the American Illuminating Engineering Society.

BRITISH ACETYLENE AND WELDING ASSOCIATION.

ANNUAL GENERAL MEETING.

THE Annual Meeting of the above Association took place at the Westminster Palace Hotel, London, on May 22nd, and was followed by the Annual Dinner at the Trocadero Restaurant in the evening.

At the afternoon meeting the President presented the report of the year, and the new President, Mr. T. E. Allen, was elected. Mr. Charles Bingham was elected Vice-President.

Before this formal business was transacted two papers were read by Mr. K. S. Murray and Mr. C. Bingham respectively on Welding Schools and the Testing of Carbide. There are already ten welding classes in various cities, and the movement is rightly considered a novel and enterprising one.

TRADE TOPICS AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

PRESS VISIT TO THE G.E.C. WORKS AT WITTON.

On Monday, 15th June, many members of the Press availed themselves of the invitation of the **General Electric Co., Ltd.**, to visit their works at Witton, and the I.M.E.A. also paid the works a visit on the following day.

The details of manufacture have been dealt with in the technical press. We would like to make special mention of the manufacture of arc light carbons, which has been brought to a high standard of perfection at Witton. As is well known, these carbons are supplied in large quantities to the Admiralty, and it is satisfactory to find that notwithstanding the severe competition of foreign manufacturers, this firm can compete successfully as regards price and quality.

We would also like to mention that the daylight illumination, while ample and even excellent in most parts of the factories, was capable of improvement in others. When daylight is insufficient the arrangements for artificial lighting should be particularly complete. No doubt the illuminating engineering department of the company will take this matter in hand and arrange for the standard of illumination to be in accordance with the progressive policy of the company.

EDISWAN SIGNS AND OTHER ACCESSORIES.

From the **Edison and Swan United Electric Light Co., Ltd.** (Ponder's End, Middlesex), we receive particulars of the Ediswan "Zenith" and "Meteor" illuminated box-signs. The essential point is the use of special thinly flashed opal glass, supplemented by white reflectors, and it is claimed that a very even distribution of light can be obtained with a single 40 watt lamp, whereas four such lamps were previously necessary.

From the same company we receive the latest catalogue dealing with Ediswan Bells, Batteries, Pushes, &c. This includes various special accessories, such as Magneto Mine Exploders, Detectors, Lightning Conductors, &c.

GAS LIGHTING IN MOSCOW.

A correspondent sends us some particulars of the gas lighting of Moscow, where a station capable of supplying approximately 1,800,000 to 4,500,000 cubic feet per day is now in existence. We understand that high-pressure gas lighting has not yet been provided, but a number of the chief streets are quite well lighted with Graetzin lamps.

At the same time many of the outlying streets are illuminated in a rather primitive fashion, many of them with open flame gas burners, and others even with oil lamps. In fact, Moscow illustrates a curious transition from Oriental to Western methods.

Siemens Contract.—We are informed that **Messrs. Siemens Bros. Dynamo Works, Ltd.**, have obtained the contract from the Royal Mail Steam Packet Co. for the supply of metal filament lamps, which includes Tantalum Lamps for Ship Lighting, and Wotan Lamps for Office Lighting, both at London and Southampton, for the ensuing 12 months.

Messrs. Falk Stadelmann and Co. (83-85, Farringdon Road, E.C.) send us particulars of the "Antarctic" Electric Motor Fans, and "Farringdon" H.V. Flat Tumbler Switches.

The Sun Electrical Co., Ltd. (118-120, Charing Cross Road, London, W.C.); Lists of the "Sun" Switch-Ceiling Rose, the Lavigne Electrical Unpickable Lock, and Fittings for "Half-Watt" Lamps.

Bristol Engineering Co., Ltd. The "Hart" heating and drying lamp, using crude oil or petroleum vapour, and useful for boiler shops, machine shops, iron and steel structural works, ship yards, &c.

INDEX, July, 1914.

PAGE

Editorial .. .. L. GASTER 331

Illuminating Engineering Society—
(Founded in London, 1909.)

Daylight Illumination of Schools, Interim Report on 359

Nomenclature and Standards, Report of the Committee of the American Illuminating Engineering Society on 335

Nomenclature and Definition of Photometric Magnitudes and Units, The .. .. A. P. TROTTER 339

DISCUSSION—Prof. S. P. Thompson—C. C. Paterson—Haydn T. Harrison—F. W. Goodenough—W. C. Clinton—E. Allen—K. Edgcumbe—Prof. J. T. Morris—W. J. A. Butterfield—J. Darch—W. J. Liberty—V. H. Mackinney—A. W. Beuttell—Dr. A. Schuster—Dr. Louis Bell—Prof. A. Blondel—Prof. Dr. H. Bunte—J. S. Dow—W. R. Cooper—J. W. T. Walsh—A. P. Trotter. 345

Illuminating Engineering, Short Notes on 369

Review of Books 374

Review of the Technical Press 372

Schools, The Daylight Illumination of 359

Trade Topics 376

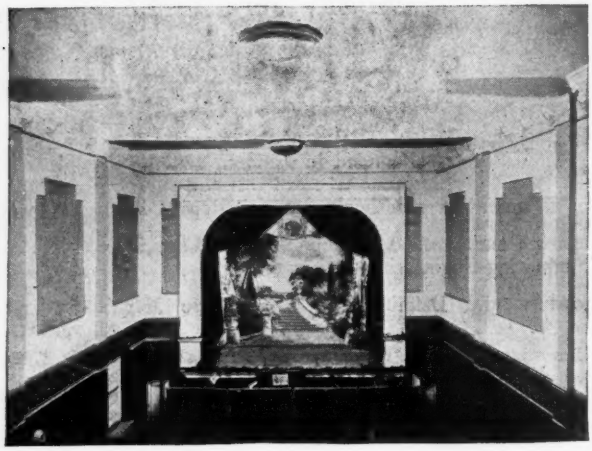
THE NATIONAL PHYSICAL LABORATORY.

The Annual Meeting of the General Board of the National Physical Laboratory took place on Friday, May 19th. Sir Wm. Crookes, President of the Royal Society, presided, and at the conclusion of the meeting there was a reception of visitors, who subsequently inspected the various laboratories.

We notice that an appeal is being made to the Government for an increase in the present grant of £7,000 per annum towards the support of the Laboratory. This appeal has received most influential support, and surely deserves careful consideration. Many people have been brought in touch with particular aspects of the Laboratory's work, but probably few realise the width and variety of the work now carried on and the relatively small support received in comparison with that given to similar Institutions in other countries.

We have little doubt that as time goes on the National Physical Laboratory will be in a large measure self-supporting. But we think the time has now come when it should receive the desired extension of Governmental support. Under the able guidance of its Director, Dr. R. T. Glazebrook, and the specially skilled staff at his disposal, the Laboratory should be able to extend its work, which will be of permanent value to the nation.

INDIRECT LIGHTING IN THE EMPIRE CINEMA, RUGBY.



This building is regarded as typical of the many picture theatres throughout the country. The lighting problem is therefore substantially the same as that usually encountered in this work. Owners of cinema palaces are now alive to the importance of good lighting in their business. Soft, well-diffused illumination, without a trace of glare, is what is required. In this case the main part of the auditorium (measuring approximately 34 ft. by 40 ft.) is lighted by a single 24-in. "**Eye-Rest**" brass bowl containing ten 80-watt **Mazda** lamps in **B.T.H. Eye-Rest** reflectors. The lights can be gradually dimmed by a metallic dimmer when a film is to be shown, and raised again after the film is finished.

In addition special lighting is provided in the vestibule, and the outside lighting, by three 600-watt **Mazda** lamps in Veluria reflectors, has made this one of the most noticeable buildings by night in Rugby.

Among other literature received from the **British Thomson Houston Co.** we note a pamphlet dealing with "Economy by Reflectors" (Holophane, Veluria, Opalux, &c.), and the last issue of *Mazda House News*. The issue contains a double page series of photos, showing Mazda lighting in a large London factory, a note on the Lighting of a Squash Rackets Court, and various other illustrated and humorous notes.

We are also asked to state that on p. 326 of our last issue a view of the illuminated Altar in St. Andrew's Church, Plaistow, was inadvertently described as belonging to St. Anne's Church, Edgehill, an installation which was also undertaken by the British Thomson Houston Co., Ltd.

"THE LIGHTING OF YOUR HOME."

This is the title of a rather singular little booklet issued by Horace F. Bowser, lighting specialist, of New York City. It is divided into eight chapters. That they deal with private house lighting on rather unusual lines will be understood from the titles of a few of these sections :— "Genesis," "Dual Existence in Design," and "The Bridegroom."

However, it puts the case for expert advice on the lighting of the home quite forcibly. An interesting feature is that Mrs. Bowser also takes part in this work. Seeing how frequently the furnishing of the home rests in woman's hands, it is only logical to suggest that she could often give good advice on the arrangement and design of lighting fittings. Her services may be particularly useful in selecting lamp shades and glassware, to match the general style of decoration; the intimate knowledge acquired by many women, where to buy any desired article at short notice, may be just what is needed to help the consumer out of a difficulty.

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON · GASTER

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EDITORIAL.

The Work of the Illuminating Engineering Society.

In this number we publish the revised List of Members of the Illuminating Engineering Society (pp. 395–418). The number now approaches 500, and as the diagram on p. 389 shows there has been a steady increase year by year.

To many outside the Society it will doubtless be interesting to see what a vast field has already been covered at the meetings so far held. We are publishing in this issue a list of the papers read, and in the case of several particularly important international discussions the names of those who took part in the discussion are also given. In addition there is a brief summary of the work accomplished in other directions, and a list of the Committees on which the Society is represented.

Collected in this way, the activities of the Society are seen at a glance, and it cannot be denied that the results are encouraging. In view of the recognition which the work already accomplished has received, it should now be easier for members to induce their friends to join and so that we may be able to do in the future even more than has been accomplished in the past.

The Care and Education of the Blind.

We have several times referred to the admirable movement for the Education, Employment, and Maintenance of the Blind, which has now found expression in a Bill before Parliament. The objects of the Bill are set forth as follows :—

> The object of the Bill is to provide for the Technical Education of the Blind by the establishment and equipment of technical schools where necessary, or by contributions to existing schools and institutions for the employment of the blind ; or by the establishment and equipment of workshops where necessary or by contributions to existing institutions providing work for the blind, for grants in respect of augmentation of wages earned by persons so employed ; for the provision of the expenses of blind persons at institutions or hostels while under technical instruction ; for the employment and maintenance of blind persons incapacitated from earning their livelihood.

Everyone must sympathise with this measure. The training of the blind in technical schools, to be established by local authorities throughout the kingdom, constitutes a great step forward. It is an organised attempt to make the lives of the blind more tolerable, and to remove one of their chief sources of suffering—the consciousness of being unable to do their share in the world's work.

The position of the blind enlists the sympathy of all classes. Anyone with a shred of imagination can appreciate to some extent what is involved in the loss of sight. Those of us who are occupied with the study of light perhaps realise it particularly keenly. But at the same time we cannot help feeling that the other side of the problem, *the prevention of blindness*, has not yet been sufficiently studied. A complete investigation into the causes of defective vision would be of immense value to future generations and would probably be a comparatively inexpensive piece of work.

The point has not yet been investigated by medical authorities sufficiently thoroughly for us to state the percentage and exact nature of troubles so caused, but the belief is gaining ground that these defects may often be traced to young people working in insufficiently lighted schoolrooms and to the strain of labour in badly illuminated offices and factories. Moreover, apart from the effect of light on the eye as an organ, it is indisputable that working by insufficient illumination is productive of fatigue and liable to injure the general health. Such fatigue manifests itself as headache, mental irritation and nervous breakdown, and this is particularly apt to occur in the case of those whose eyesight is already weak and likely to become worse, unless treated in time. In these days we turn night into day. We carry through our work at high pressure, and tax our eyes far more than our forefathers did. Would it not be well to establish co-operation between lighting engineers and medical men with a view to gradually tracing and removing these bad conditions ? This is a piece of work which might well be conjointly carried out with the National Institute for the Blind, whose president-elect, Mr. C. A. Pearson, has devoted himself so ungrudgingly to the cause of the sightless.

The Problems of Street Lighting.

In the recent discussion of the proposed standard clauses for a specification of street lighting the need for more definite agreement as to what constitutes good street lighting early became evident. As yet the object-lessons served by installing street lamps have hardly been sufficiently analysed; there have been many experiments conducted (not infrequently the same ground has been covered again and again) on the question of *cost*. But only rarely has there been any deliberate attempt to install various systems of lighting over the same length of street with a view to ascertaining the effect on traffic and observers.

A noteworthy step in this direction has been taken by the Street Lighting Committee formed by the National Electrical Light Association (U.S.A.), to which we drew attention in our last number (p. 370). In a preliminary report the Committee describes a most interesting series of researches, now proceeding. A typical street has been selected in New York City. This is to be divided into two halves, which can be lighted in succession in a variety of ways. The usual record of gas and electricity consumed will be kept and very complete photometric data as regards candle-power of lamps, illumination on street surface, vertical illumination and surface-brightness of surrounding objects will be taken. But in addition an attempt is being made to classify the " visual effect " of the various systems and the impression left by them on the " man in the street." Observers will be asked to patrol the street and give their general impressions. Subsequently they will revise their judgment while riding on tramcars. Finally their attention will be invited to certain specified points, such as ability to distinguish the faces of people and approaching vehicles, and to detect irregularities on the roadway and pavement. Other ingenious tests are being devised. For example, observation targets consisting of galvanised iron plates are to be distributed through the streets at irregular intervals, and observers will be asked to state the percentage of targets detected by the eye in the two portions of streets compared. This will furnish one criterion as to the detail-revealing power of the two systems. It is interesting to note that the Committee have secured the co-operation of Dr. Hugo Munsterberg, Professor of Psychology at Harvard University, who is analysing the part played by mental impressions in connection with street lighting.

In the Report before us the line of research is sketched out and the results of a few researches summarised. The final report should be a most interesting document. We have often expressed the view that similar researches should be undertaken in this country by a central impartial testing department.

Illumination in Parks and Gardens.

We have recently pleaded for a more generous provision of illumination in some of the large London parks, which might surely be much more used by the public on summer evenings. The same applies to the small green oasis in the centre of many squares, which forms an attractive contrast to the monotonous grey of buildings by day, but is not infrequently a sombre and gloomy spectacle by night.

To carry the idea a step further, we may suggest that even in private gardens light might be used with good effect on summer evenings—an idea that is developed in an article on p. 421. When people are on a holiday they frequently prolong their walks in the twilight. The seaside parade is invariably brightly lighted as a matter of course, and in some enterprising resorts electric light is even led out to the tents on the beach. Walkers describe this as " the best part of the day." Why, therefore, do not people make more use of their gardens by night ?

Probably it is mainly a matter of custom. It is only gradually that people have come to recognise that with the setting of the sun the day is not ended. Indoors the day is now prolonged with artificial light. In time to come artificial light will be used in gardens in the same way.

To the consumer who has gas or electricity laid on it is a simple matter to lead out mains or pipes and to get light on the verandah, in the conservatory or in the summer house ; even to arrange occasional lights amidst rockeries and foliage. But the country consumer who has neither gas nor electricity available is by no means at a disadvantage. There are now many portable lights available which can readily be used in the gardens for parties and on festive occasions.

Then there is the special inducement of using artificial light for games. To the average man who has little leisure during the day this is a most attractive possibility, and in the country, where opportunities for entertainment are fewer, covered courts, devoted to lawn tennis, squash racquets, &c., would be invaluable on wet afternoons and in the evening. It will be observed that this is a new use for artificial light. It does not take away business from any particular illuminant and transfer it to another. The large country mansion with its private generating plant could readily light such courts by electricity. But for such purposes acetylene, petrol air gas, and incandescent oil could also be applied.

Continental visitors to London not infrequently remark on the lack of outdoor entertainments by night, and on the absence of the cafes and beer-gardens which play such an important part in the life of such cities as Paris and Berlin. The climate in this country has often been blamed ; but recent experience suggests this is not an insuperable obstacle, and that with a little enterprise much more effective use of our parks and gardens might be made.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

HARMFUL RADIATIONS AND THE PROTECTION OF THE EYES THEREFROM.*

(Report issued by a Research Committee appointed by the Illuminating Engineering Society, U.S.A., and consisting of Messrs. Bond, Amrine, Cobb, Langdon, Powell, Richtmyer, Dr. Geo. S. Crampton, and Dr. H. E. Ives. Letters containing suggestions were also received from Messrs. Lancaster, Crittenden, and Nutting.)

THE discussion was begun by an attempt to summarise our present knowledge. This brought out at once the necessity of clearly distinguishing between radiations specifically harmful and radiations which have a harmful effect merely because their source (illuminant) is improperly used. Instances were cited where it was probable that investigators worked with lighting installations so poorly arranged that the ill effects quoted might be due partly or wholly to the exposure of the eyes to over-bright light sources.

Another clear distinction necessary to be made is whether the harmful effects take the form of physical injury to the tissues of the eye, or of functional disturbances. A survey of published researches shows that a very large percentage of these deal only with studies of physical injury, such as inflammation, cataract, &c. This has been due in large measure to the fact that tests for functional disturbances, for the effects of cumulative or repeated exposure, are almost unknown.

What Radiations are Harmful?

On taking up the question: "What radiations are harmful?" it developed that a common defect of recorded work is absence of quantitative data. It is often impossible to separate the effects of quality of radiation from quantity or intensity. Sufficient care has not been taken in isolating the radiations of the particular wave-lengths which are supposed to be harmful. Thus in work with ultra-violet light very few experimenters have tried the effects of ultra-violet radiations alone, *i.e.*, with no visible rays. In many cases the supposedly harmful light sources have had present an enormous preponderance of infra-red or heat radiation. A case in point is "glass workers cataract," frequently ascribed to the ultra-violet light, yet caused (if indeed it is proved to be unduly prevalent among glass workers) by the radiation from furnaces and hot glass overwhelmingly predominant in infra-red.

In spite of these criticisms of many experiments on ultra-violet light, there seems to be no doubt that ultra-violet light of certain wave-lengths is

* Trans. Illum. Eng. Soc., U.S.A., Vol. IX., 1914, p. 307.

intrinsically harmful to the anterior portions of the eye which receive, and by their absorptive characteristics protect, the posterior portions. Functional disturbances due to the cumulative effects of prolonged or repeated exposure are not fully investigated, and one test, that on the time of adaptation, which appears promising, has been made apparently only with total radiation, rich in infra-red.

It appears that the possible effects of infra-red radiation have been somewhat neglected, especially in view of the fact that most artificial illuminants are so rich in heat radiation. Direct physical injury is apparently not to be expected from these rays, unless of such intensity as to actually burn.

More Quantitative Data Needed.

Both in the case of ultra-violet and infra-red there appears to be a lack of definite quantitative data on the transmission of the media of the living eye.

Some time was spent in discussion of the amount of ultra-violet and infra-red radiations in ordinary illuminants. Emphasis was laid on the fact that, for the same brightness, most artificial sources have far less ultra-violet than daylight, although much more infra-red. It was however brought out that the difference between the brightness of the illuminant and of most illuminated objects was far greater than is experienced by day, so that these comparative figures might in practice be misleading. Attention was called to the fact that the state of adaptation of the eye for artificial light is different than for daylight and may greatly alter its susceptibility.

Protecting Glasses.

The discussion concluded with the subject of protective glasses. In view of the indefiniteness of our knowledge as to what radiations are actually harmful, the question of what kinds of glasses would be protective is not capable of very definite answer. The physical injury due to ultra-violet radiation can unquestionably be stopped by glasses opaque to those rays, so that a simple spectrographic test can determine the good protective glasses. When, however, the actual discomfort or functional disturbance is due to improper distribution, or excessive intrinsic brilliancy, it is doubtful whether protective glasses are the proper remedy. As far as intrinsically harmful radiations are concerned, once we have definite knowledge of what to exclude it is a comparatively simple physical problem to determine the efficacy of a given glass.

Suggestions for Future Work.

A number of problems are suggested as worthy of investigation by those equipped for this kind of work. In suggesting these problems the Committee's indebtedness to suggestions of members of last year's Research Committee is appreciatively acknowledged.

The problems suggested are as follows :—

(1) Pathological studies of the effects of infra-red radiation, similar to studies already carried out on ultra-violet light.

(2) A quantitative determination of the transmission of various eye media throughout the visible and invisible spectrum, both in living and dead eyes.

(3) The development of functional tests, suited to show the effects of long continued or occasional exposure.

(4) A pathological study of the possible effects of a cumulative nature which may result from prolonged or repeated exposure to radiations not sufficiently intense to produce immediate harmful effects which can be detected.

(5) An investigation to decide whether the effects of harmful radiations depend upon the state of adaptation of the eye.

(6) To what substance is due the fluorescence of the retina under ultra-violet light ?

(7) A study of the adaptation time of the retina as a possible test of functional impairment, and its use with different radiations.

(8) Determination of the specific bactericidal action of various invisible radiations.

In attacking any of these problems special attention should be directed to :—

(1) The reduction of all results to definite wave length and energy values.

(2) The clear differentiation between radiations intrinsically harmful and those improperly used.

(3) The necessity for knowing the condition of the eyes used, as shown by proper tests of vision.

Co-operation between Physicists and Physiologists.

The foregoing makes clear that any work on this question must be done with the help of expert judgment, in both its physical and physiological aspects, with respect to the photometric and spectrometric conditions of the experiment on the one hand, and on the other with respect to the physiological and pathological conditions applying to the eye under experimentation. The literature shows that this necessary condition is not always fulfilled.

Translations of some of the recent foreign papers have been offered for the committee's use by Dr. Crampton. Information concerning these and other matters above discussed will be furnished by the committee upon application.

A set of spectrograms of transmissions of several commercial glasses were furnished by Dr. Nutting and will be kept on file. The correspondence between the various members of the committee and the Chairman, containing in greater detail the material of which this report is a summary will also be on file and may be consulted by interested parties.

HERBERT E. IVES,
Chairman.

[The report is concluded by a most valuable series of over 200 references to the literature of the subject. Ed.]

GERMAN ILLUMINATING ENGINEERING SOCIETY.

NOTES ON THE PROCEEDINGS AT THE LAST MEETING ON MARCH 28TH.

AT this meeting papers were presented by Dr. W. Voege on "Objective Photometry" and by Dr. Jakobson "Train Lighting."

Several other items of interest were discussed. Herr Liebenthal stated that the German Illuminating Engineering Society was to act as the National Committee on Illumination in that country, and announced that Dr. Brodhun and Dr. Krüss had been selected to represent the Society as delegates on the International Commission.

A discussion also ensued as to where and when the annual meeting should be held. Herr Warburg recommended Nürnberg, and most of those present were in favour of the meeting taking place in the middle of September. He added that, in response to the wish of members, an official list of the Society and cards of membership would be issued shortly.

Reference was made to the work of the three committees appointed to deal with Units, Nomenclature, and Photometry. The last-named committee has already issued the following recommendations relating to the valuation of light sources:—

A source of light is to be estimated in terms of three quantities, Mean Spherical c.p., Mean Lower Hemispherical c.p., or Mean Horizontal c.p. It should be clearly indicated which of these three quantities is specified.

From a purely physical standpoint the Mean Spherical c.p. is the most important quantity. But on practical grounds it is often inconvenient to depart from the hitherto usual practice of expressing the light from a source in terms of Mean Horizontal or Mean Lower Hemispherical c.p.

Therefore, the Committee recommends that when these values are used the factor for conversion to Mean Spherical c.p. should also be mentioned.

It is added that these are merely interim recommendations and it is proposed to invite the co-operation of the Verband deutscher Elektrotechniker and the Verein von Gas- and Wasserfachmännern in these matters.

SHELLS AS AERIAL SEARCHLIGHTS.

In the autumn military manœuvres in France much interest was taken in a new form of "luminous projectile." Roughly, it may be described as shells adapted to field-pieces instead of to howitzers. It is probable that the new kind, which, whilst bursting, shed a vivid light, revealing the enemy without revealing the opposing force, will be tried in night attacks.

THE EYE PROBLEM IN THE SCHOOLS.

Under this title Dr. A. J. Ladd, Professor of Education, at the North Dakota State University recently dealt with the problem of school lighting.* Dr. Ladd makes a plea for greater foresight in the preparation of books for children, the use of type of a convenient large size, and the employment of unglazed soft tinted paper. Small type and highly-glazed paper is apt to be trying to young eyes.

Dr. Ladd remarked :—

"We are told by our scientific friends the relative amounts of window and floor space that the schoolroom should have in order to be adequately lighted for young eyes. But how seldom do we find a school house that is adequately lighted! Not one in ten has as much window space as it should have, and a good portion of what has been provided is frequently covered by shades through the teacher's perverted notion of relative values—seeming to have greater appreciation for the certain so-called artistic effects than for eye comfort and safety in work.

"And then, again, these scientific friends of ours have told us that there should be in the schoolroom no cross lights; that the light should not shine upon the blackboards, nor into the faces of the children, but that it should come only from the rear and the left and from above. They have found out, too, and told us the proper shades of colour for the walls—scientific knowledge, all of it, and therefore thoroughly reliable. But how systematically do we disregard all this valuable information! In the construction of a new school building there is nothing that should receive more careful and scientific consideration than the matter of lighting, but too often the architect is either entirely ignorant of the entire matter, or else is selfishly interested in so-called architectural effects.

I do not mean that we all disregard all these things, that we have no school houses properly constructed, no school books properly printed, and no teachers intelligent and sensible in their handling of boys and girls. Not at all. During the last twenty years we have made long strides in advance along many of these lines in many places. But the bright spots are still the exception and not the rule. The friends of children and of the race need to keep vigilantly at work."

There is plenty of statistical evidence to show that the eyes of children suffer. An investigation carried out in Jefferson City, Mo. (1907-1908), shows that 29 per cent. of scholars in grades 1 to 3 were found to have defective vision, and in the higher grades, 9 to 12, as many as 40 per cent. were handicapped in this way. But in the course of some tests carried out by Dr. Wallin in Cleveland, Ohio in 1906-1910, a school was found in the congested district of the city, where as many as *71 per cent.* of children were defective. Similarly a test in Los Angeles, California, in 1909 shows that 5,000 children were examined and 61 per cent. possess a more or less defective vision.

No doubt these are conspicuously bad examples, but they show to what lengths this evil may sometimes go. Dr. Ladd advocates that the architecture of schools should be more carefully considered from the lighting standpoint. Architects and boards of education should realise that the seating and lighting of school houses must receive more careful attention. We should appreciate the unwisdom of being "penny wise and pound foolish." In the long run the perpetuation of defects which handicap children in after life, and limit their usefulness as citizens, is bound to be uneconomical.

Naturally time is going to bring about the desired change of condition. We may quote some of Dr. Ladd's concluding words :—

"Large bodies move slowly. We must have patience. We must keep steadily at it, preaching the good gospel of reform."

This is what the Illuminating Engineering Society is doing in this country.

* *Optical Journal*, May 14th, 1914.

THE LIGHTING OF STATUES.

The accompanying two photographs, kindly sent us by Mr. Justus Eck, were taken in the Botanical Gardens of Ballarat (Australia). They represent the figure of Susannah.

The pictures are interesting as an example of the problems involved in lighting statuary. People are apt to think that the illumination is good if the shadows are exceptionally well marked. Yet, from the artistic standpoint, this is not the correct view.

The right hand illustration is possibly the better from the purely photographic standpoint, as the shadows are more definite. But the result is that the figure looks like a marble statue rather than an actual human being. The left hand figure is considered to bear a more decided resemblance to a human form even though the shadow is not so marked and the general impression is softer.

A considerable amount of trouble was taken to get the lighting of this statue as correct as possible. The view shown on the left was taken by the conditions of illumination ultimately adopted, which are now very carefully maintained. There are other statues in these Botanical Gardens which are also exceptionally well lighted, but the figure of Susannah is considered quite the most successful in this respect.

Soft Illumination. Gives the effect of a living figure.

Somewhat more definite shadow. Looks like a marble statue.

THE NOMENCLATURE AND DEFINITION OF PHOTOMETRIC MAGNITUDES AND UNITS.

(Further discussion of a paper on the above subject read by Mr. A. P. Trotter at a meeting of the Illuminating Engineering Society on May 21st, 1914.)

Lord Rayleigh (*communicated*) :—

I am a good deal in sympathy with your paper and with the remarks of Dr. Schuster. It may be true that the more scientific system is to start from flux, but we must also consider intelligibility (to the ordinary man) and convenience. In the case of sound, referred to by Mr. Paterson, we have nothing like a standard source of sound available.

I do not think we ought to say that a lamp has a candle-power of 16 candles. It should suffice to say a power of 16 candles. If we must have another word, it should be a lamp-power. A glow worm, or the sun, has a lamp-power of so many candles (in one part of the spectrum). I cannot help thinking that experts are too ready to introduce new words. A good deal of technical electrical writing is becoming unintelligible even to those who have had a hand in laying its foundations.

A FUNDAMENTAL PRINCIPLE IN ILLUMINATION.

Under this title, Dr. H. E. Ives makes a contribution to the *Transactions* of the Illuminating Engineering Society (U.S.A.) in which he attempts to summarise the requirements of artificial lighting in one fundamental principle. Dr. Ives suggests that the eye is invariably attracted to the brightest object in the field of view and adjusts itself according to the brilliancy of this object.

For this reason one should arrange the light in such a way that when the eye must be concentrated on a certain spot (*i.e.*, in tending a machine, reading a book, or looking at a picture) the object viewed should always be brighter than its surroundings.

From this Dr. Ives is led to a second conclusion : "The light source illuminating an object under observation must be concealed, no matter what its intrinsic brilliancy."

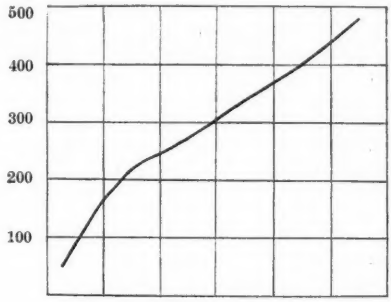
For it is common knowledge that whatever the luminous source be, whether a lamp, an illuminated ceiling, or the sky, it will always be brighter than the things it illuminates. From a theoretical standpoint there is doubtless much to be said for this suggestion, especially in those cases in which the eye is constantly fixed on a particular object. But it is less certain whether it ought to be rigidly applied when the eye desires to rove at will.

THE WORK OF THE ILLUMINATING ENGINEERING SOCIETY.

THE Illuminating Engineering Society was formed in London in 1909. Its membership has now increased to nearly 500, and the adjacent diagram shows the steady increase in members year by year.

But now the time has come when the Society requires a greatly enlarged membership in order to carry out the important work before it and extend its activities.

In the following pages we are summarising the work so far done. We think that those who read the account will agree that this is a movement which deserves the fullest recognition.



Growth of Membership of the Illuminating Engineering Society, 1909—1914.

WHAT THE SOCIETY HAS DONE.

The Illuminating Engineering Society has provided **a platform for the impartial discussion of illumination,** a friendly meeting place for architects, medical men and engineers connected with all methods of lighting. It is most important to the lighting industry that **this atmosphere of " fair play " should be maintained.**

During its five years of existence the Society has held **37** meetings. The **total attendance,** obtained by adding up the number of people present at each meeting, approaches **3,000,** approximately 60 per cent. of whom were visitors. Upwards of **300** contributions have been made to the discussions, and more than **200** different people have either spoken or communicated remarks at these meetings.

The proceedings have been regularly reported in the official organ, THE ILLUMINATING ENGINEER, and have received a unique and widespread attention in the technical and daily press. **The Journal is habitually quoted by over 100 periodicals** and the movement is thus **brought to the notice of millions of people every year.**

Besides appealing to the general public, **the movement receives support from many distinguished engineers and scientific men.** The list of Vice-Presidents (p. 395) shows the nature of support received. The fact that **the President** for the year is **Sir William Bennett, K.C.V.O., F.R.C.S.,** Surgeon to H.M. the King, is sufficient evidence that it makes **a strong appeal to the medical profession,** the " guardians of the public health."

But the movement also **enlists the sympathy of those associated with pure and applied science, engineering and architecture.** For example, at the last Annual Dinner the Society was honoured by the presence of, among other distinguished guests, the **President of the Royal Society,** the **President of the Institution of Gas Engineers, Vice-Presidents of the Institution of Electrical Engineers and the Royal Institute of British Architects,** and the **Secretary of the Royal Society of Arts.**

The Society interests all classes. It brings the manufacturer of lighting appliances in contact with the actual user of them. For example, when discussing Library Lighting a **Joint Meeting with the Library Association** was arranged ; subsequently the proceedings were reprinted by the Library Association and distributed among all its members. Similarly, when dealing with **School Lighting** the co-operation of medical and educational authorities was secured. Subsequently **Joint Committees on School and Library Lighting** were formed. These Committees have already issued interim

reports on these subjects, which have received attention in most influential quarters. Already, through the work of our Society the standard of lighting in many schools through the country is being raised.

The Illuminating Engineering Society was also instrumental in forming the **Joint Committee on the Standard Specification for Street Lighting,** on which, for the first time, delegates from the Institutions of Gas, Electrical, and Municipal and County Engineers worked together. Wishing to provide an opportunity for open discussion of this difficult subject the Committee determined to avail themselves of the impartial platform of the Illuminating Engineering Society. The paper read by Mr. A. P. Trotter on the subject attracted notice far and wide throughout the country and has already done much to raise the status of street lighting.

Since the illuminating engineering movement was started a continually increasing amount of attention has been paid to illumination in the reports of H.M. Chief Inspector of Factories. This has culminated in the **appointment by the Home Secretary of a Departmental Committee to inquire into Industrial Illumination.**

Arrangements are now being made to extend the membership of the Society throughout the provinces. Representatives in the following cities have already been nominated. Arrangements are now being made for other cities in various parts of England, of which particulars will be announced in due course. Representatives in the following cities have already been nominated.

BIRMINGHAM.
Mr. Justus Eck, Manager and Chief Engineer of the Union Electric Co.

GLASGOW.
Mr. W. W. Lackie, Chief Engineer to the Glasgow Corporation Electricity Dept.
Mr. Alex. Wilson, Chief Engineer to Glasgow Corporation Gas Works.

LEEDS.
Mr. W. D. Helps, Managing Director of Messrs. Jas. Milne & Co.

LIVERPOOL.
Mr. E. Allen, Chief Engineer of the Liverpool United Gas Co. (Past President of the Institution of Gas Engineers.)
Dr. E. W. Marchant, Professor of Electrical Engineering at Liverpool University.

MANCHESTER.
Mr. S. L. Pearce, Chief Electrical Engineer to the Manchester Corporation.
Mr. J. G. Newbigging, Chief Engineer, The Gas Works, Manchester.

The scope and membership of the Illuminating Engineering Society are **not only National, but International.** It has now **over 120 Corresponding Members** in various cities in Europe and the United States who are constantly taking part in the discussions of the Society on subjects on which they are recognised authorities. In this way members are kept fully informed of what is taking place abroad.

In addition, the Illuminating Engineering Society has been represented at **many important International Congresses,** where its members have brought forward the claims of good illumination. Among these Congresses may be mentioned :—

The International Congress on Industrial Hygiene (Brussels, 1910).
The International Hygienic Congress (Dresden, 1911).
The International Electrical Congress (Turin, 1911).
The First International Congress for the Prevention of Industrial Accidents (Milan, 1912).
The Fourth International Congress on School Hygiene (Buffalo, 1913).
The Annual Congress of the Royal Institute of Public Health (Paris, 1913).

An Illuminating Engineering Society has now been formed in Germany, with similar aims to the Society in England and the Society founded in the United States in 1906. A special Journal has been started to deal with illumination in France. Keen interest in the subject is being shown in other countries.

Finally, again largely owing to the existence of the Illuminating Engineering movement, an **International Commission on Illumination** was formed last year. National Illumination Committees have been formed in all the chief countries, and they in turn will report periodically to the International Commission on Illumination. This is a piece of work by which **the lighting industry throughout the world will benefit.**

LIST OF PAPERS READ BEFORE

The Illuminating Engineering Society

(Founded in London 1909)

1909—1914.

Date.	Subject of Paper.	Author.	No. of people taking part in Discussion.
1909.			
Nov. 18	**Inaugural Address**	**Dr. Silvanus P. Thompson**	
1910.			
Jan. 11 & Feb. 15	**Glare, Its Causes and Effects***	**J. Herbert Parsons**	
	Discussed by :—		
	Great Britain—Dr. F. W. Edridge Green, Dr. F. Gans, Dr. J. Kerr, Dr. W. Ettles, Dr. T. M. Legge, Dr. W. M. Bayliss, Mr. P. J. Waldram; A. P. Trotter, J. H. Agar Baugh, J. S. Dow, W. R. Cooper, W. M. Mordey, Haydn T. Harrison, V. H. Mackinney, L. Gaster, Dr. S. P. Thompson, Dr. E. H. Nash, Dr. W. Ettles, Prof. G. J. Burch		
	Abroad—Dr. K. Stockhausen (Dresden), Prof. L. Weber (Kiel), Dr. Corsepius (Cologne), Dr. L. Bell (Boston), Dr. E. P. Hyde (Cleveland), Prof. R. Ulbricht (Dresden), Dr. L. Bloch (Berlin), M. Lauriol (Paris), Prof. S. A. Rumi (Genoa), Dr. W. H. Seabrook (New York), Dr. E. O. Sisson (Denver), Dr. W. Voege (Hamburg), Dr. H. Krüss (Hamburg), Prof. H. Strache (Vienna), H. Prenger (Cologne), Dr. H. Lux (Berlin), Prof. A. Grau (Vienna), Messrs. Körting and Mathiesen (Berlin), C. H. Williams (Boston)		19
Mar. 15 & April 14	**The Measurement of Light and Illumination*** (General Discussion)		
	Discussed by :—		
	Great Britain—Prof. A. E. Vernon Harcourt, Dr. J. A. Fleming, A. P. Trotter, C. C. Paterson, Dr. W. E. Sumpner, W. J. Liberty, Prof. J. T. Morris, J. S. Dow, L. Wild; J. G. Clark, Haydn T. Harrison, P. J. Waldram, K. Edgcumbe, L. Gaster, W. R. Cooper, G. F. Boxall		16
	Abroad—Dr. K. Stockhausen (Dresden), Dr. L. Bell (Boston), Dr. C. H. Sharp (New York), G. H. Stickney (Schenectady), F. Lauriol (Paris); Prof. A. Blondel (Paris), Dr. Corsepius (Cologne), W. J. Cady (New York), A. A. Wohlauer (New York), N. Macbeth (New Jersey)		10
April 14	**The Direct Measurement of the Total Light Emitted from a Lamp**	**Dr. W. E. Sumpner**	6
Nov. 8	**Recent Progress in and the Present Status of Gaslighting**	**F. W. Goodenough**	13
Dec. 9	**Recent Progress in Electric Lighting**	**Dr. W. E. Marchant**	16
	Note on the Blackening of Tungsten Lamps	**G. W. Howe**	
1911.			
Jan. 16 & Jan. 31	**The Artificial Lighting of Libraries** (Joint Meeting with the Library Association)	**J. Duff Brown, L. S. Jast, J. Darch**	25
Feb. 16	**The Natural Lighting of Schools**	**Dr. J. Kerr**	
	The Artificial Lighting of Schools (Joint Meeting with the Association of Medical Officers in Schools, the London Teachers' Association, and the Association of Technical Institutions)	**Dr. N. Bishop Harman.**	25

List of Papers read before the Illuminating Engineering Society—(*continued*):—

Date.	Subject of Paper.	Author.	No. of people taking part in Discussion.
April 24	**Interior Illumination and the Reflecting Power of Walls and Ceilings**	**Haydn T. Harrison and P. J. Waldram**	12
Nov. 17	**Notes on the Design of Motor-Car Headlights**	**Dr. H. R. B. Hickman**	10
Dec. 19	**Lighting of Railway Stations and Goods Yards**	**Haydn T. Harrison**	15
1912.			
Jan. 16	**Colour Discrimination by Artificial Light**	**T. E. Ritchie**	15
Feb. 20	**Shop Lighting by Electricity**	**N. W. Prangnell**	16
	Shop Lighting by Gas	**A. E. Broadberry**	
Mar. 19	**Illumination of Printing Works by Electricity**	**J. Eck**	11
	Illumination of Printing Works by Gas	**F. W. Goodenough**	
April 15	**Private House Lighting by Electricity**	**W. R. Rawlings**	12
	Private House Lighting by Gas	**W. H. Y. Webber**	
Nov. 19	**Recent Progress in Illuminating Engineering**	**L. Gaster**	12
	A New Illumination Photometer	**Haydn T. Harrison**	
	Photography in Illuminating Engineering	**J. S. Dow**	
	Apparatus to Illustrate Reflection from Walls and the Ceiling	**Prof. W. C. Clinton**	
Dec. 3	**Modern Methods of Indirect Lighting**	**F. W. Willcox and H. C. Wheat**	14
1913.			
Jan. 14	**Acetylene Lighting**	**C. Hoddle**	15
	Petrol-Air Gas Lighting	**E. Scott Snell**	
Feb. 18	**Some Notes on the Use of Shades and Reflectors**	**J. G. Clark and V. H. Mackinney**	14
Mar. 11	**The Centenary of Gas Lighting and its Historical Development**	**W. J. Liberty**	5
April 15 & April 29	**Standard Clauses for Insertion in a Specification of Streetlighting***	**A. P. Trotter**	
	Discussed by :—		
	Great Britain—W. H. Patchell, F. W. Goodenough, Haydn T. Harrison, R. Watson, J. G. Clark, F. Thorp, K. Edgcumbe, J. Darch, H. T. Wilkinson, Prof. J. T. Morris, J. W. Bradley, F. Bailey, E. Allen, Roger T. Smith, W. R. Cooper, J. Abady, L. Gaster, N. W. Prangnell, S. L. Pearce, H. A. Ratcliff, J. G. Clark, J. S. Dow, W. J. Liberty		23
	Abroad—Dr. L. Bloch (Berlin), Dr. L. J. Terneden (Amsterdam), Prof. H. Strache (Vienna), Prof. S. A. Rumi (Genoa), Dr. L. Bell (Boston), L. B. Marks (New York), Dr. C. H. Sharp (New York), P. S. Millar (New York).		

List of papers read before the Illuminating Engineering Society—(*continued*):—

Date.	Subject of Paper.	Author.	No. of people taking part in Discussion.
1913.			
Nov. 18	**Report of Progress during Vacation**	**L. Gaster**	
	Illumination at the National Gas Exhibition	**F. W. Goodenough**	
	Some Notes on the Fourth International Congress of School Hygiene	**Dr. James Kerr**	
	Shadows by Natural and Artificial Light	**J. S. Dow and V. H. Mackinney**	5
	The Importance of Direction, Quality and Distribution of Light	**M. Luckiesh**	
Dec. 16 &	**Some Problems in Daylight Illumination***	**P. J. Waldram**	
1914.			
Jan. 15	Discussed by:—		
	Great Britain—G. Widdows, Dr. J. Kerr, J. S. Dow, F. R. Farrow, Dr. E. H. Nash, A. P. Trotter, W. C. Clinton, H. L. Dunstall, C. C. Paterson, P. L. Marks, W. H. Webb, Dr. F. Gans, J. S. Dow, V. H. Mackinney, L. Gaster, T. E. Ritchie, L. Warren, P. J. Waldram		18
	Abroad—Prof. L. Weber (Kiel), Dr. F. Pleier (Karlsbad), Dr. L. Burgerstein (Vienna), Dr. F. Altschul (Prag), Dr. Erisman (Zurich), Dr. Kaz (St. Petersburg), Prof. Richtmeyer (Ithaca, U.S.A.), Dr. Max Grüber (Munich)		8
Feb. 17	**The Lighting of Picture Galleries and Art Studios**	**Dr. Silvanus P. Thompson**	15
Mar. 17	**A Comparison of Estimated and Observed Values of Illumination in Some Lighting Installations**	**W. C. Clinton**	13
April 7	**The Lighting of Railway Carriages and other Public Vehicles (Discussion)**		9
May 21	**The Nomenclature and Definition of Photometric Magnitudes and Units**	**A. P. Trotter**	
	Discussed by:—		
	Great Britain—Dr. S. P. Thompson, C. C. Paterson, Haydn T. Harrison, F. W. Goodenough, W. C. Clinton, E. Allen, K. Edgcumbe, J. T. Morris, W. J. A. Butterfield, J. Darch, W. J. Liberty, V. H. Mackinney, A. V. Belltell, Dr. A. Schuster, J. S. Dow, W. R. Cooper, J. W. T. Walsh		17
	Abroad—Dr. L. Bell (Boston), Prof. A. Blondel (Paris), Prof. Dr. H. Bunte (Karlsruhe)		3
			320

* In the case of subjects of International interest, and on which much difference of opinion was found to exist, the corresponding members of the Society in various countries were invited to express their views. In these instances we are reproducing the names of those both in this country and abroad, who joined in the discussion, in order to illustrate the value of the international platform of the Society in dealing with problems of this kind.—ED.

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(Founded in London 1909).

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(FOUNDED IN LONDON 1909).

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Honorary Members may be chosen from among those who are of acknowledged eminence in some branch of science related to illuminating engineering, or who, by reason of position, eminence, or experience, may be enabled to render assistance in promoting the aims of the Society. (Article 5 in the Constitution of The Illuminating Engineering Society.)

Moeller, Dr. A. — President of the Academie Royale de Médecine, Member of the Commission des Accidents du Travail, 1, Rue Montoyer, BRUSSELS. (Elected 1910.)

In recognition of valuable services as President of the Congrès International des Maladies Professionnelles, Brussels, 1910.

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M.C.		WALDRAM, P. J. *F.S.I.*	Surveyor, Civil Engineer, 12, Buckingham Street, Charing Cross, LONDON, W.C. (1).
		Walker, F. J.	Managing Director, St. James's and Pall Mall Electric Supply Co., 19, Carnaby Street, Golden Square, LONDON, W. (1).
		Walker, H.	Surveyor to the Law Union and Rock Insurance Co., 1, Old Serjeant's Inn, Chancery Lane, LONDON, E.C. (1).
		Walker, R. E.	Elec. Engineer and Contractor, Widemarsh Street, HEREFORD (2).
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		Walsh, B. P. K.	123, Queen's Road, Finsbury Park, N. (4).
		Walsh, J. W. T., *B.Sc., B.A. (Oxon.)*	Observer to Home Office Committee on Factory Lighting, 5, Haggard Road, TWICKENHAM (1).
		Walters, A. E.	Lighting Inspector on the N.S. Wales Govt. Railways, Shiplake, Parramatta Road, CONCORD, New South Wales (4).
		Walters, E. H.	Engineer-in-Chief's Office, G.P.O., LONDON, E.C. (4).
		Walton, W. H.	Elec. Engineer, Messrs. Pinching & Walton, 52, Cannon Street, LONDON, E.C. (4).
		Watson, J. F. *M.I.C.E., M.I.M.E.*	Consulting Engineer, Sun Buildings, Park Road, LEEDS (1).
		Watson, R.	Chief Engineer, The Gas Works, DONCASTER (3).

	Wearing, A. B.	Electrical Engineer, Managing Director of the Canadian Union Electric Co., Ltd., 9, St. St. Nicholas Street, MONTREAL (2).
	Webber, W. H. Y.	Gas Engineer, Staff Instructor to the Gas Light and Coke Co., Isca, Udney Park, Teddington (1).
V.P., C.M.	**Weber, Prof. L.,** *Ph.D.*	Professor of Physics at the University of Kiel, Moltkerstr. 60, KIEL, Germany.
V.P.	**Wedding, Prof. Dr. W.**	Professor at the Technische Hochschule, Charlottenburg, Gross Lichterfelde, Wilhelmstrasse, 2, BERLIN.
	Weekes, R. W. *M.I.E.E.*	Consulting Engineer, Maxwell House, Arundel Street, Strand, LONDON, W.C. (2).
C.M.	Weinbeer, E. W.	Electrical Engineer and Professor of Electrotechnics at Charlottenburg, 4 Röntgenstr., CHARLOTTENBURG, Germany.
	Weiss, A., *A.M.I.E.E.*	Electrical Engineer, General Electrical Company, Osram Lamp Department (Technical Section), 1, Highbury Hill, LONDON, N. (1).
	Westlake, W. N.	Manager of the Exeter Gas Light and Coke Co., 11-12, East Southernhay, EXETER (4).
	Weston, G. C. *A.M.I.E.E.*	Distribution Engineer to Kensington and Knightsbridge Electric Lighting Co., Prince Consort Road, South Kensington, LONDON, W. (1).
	Wheat, H. C.	Lighting Engineer to the British Thomson-Houston Co., B.T.H. London Lamp Works, Willesden (1).
C.M.	Whitney, Dr. W. R.	Director of Research Laboratory, General Electric Co., Schenectady, N.Y., U.S.A.
	Whyte, W.	Corporation Gas Works, ROTHESAY, Scotland (4).
	Wild, L. *M.I.E.E.*	Director of the Westminster Electrical Testing Laboratory, York Mansions, York Street, LONDON, S.W. (1).
	Wilkinson, H. T.	Managing Director of the Wardle Engineering Co., 196, Deansgate, MANCHESTER (4).
	Willcox, F. W.	The British Thomson-Houston Co., Mazda House, 77, Upper Thames Street, LONDON, E.C. (4).
	Williams, J.	General Manager of the Foreign and Colonial Lighting Co., Ltd., Emberton Lodge, NEWPORT PAGNELL, England (1).
	Williams, W. H. *A.M.I.E.E.*	Manager of Lamp Dept. of the Electrical Co., 115, Lower Richmond Road, East Sheen, LONDON, S.W. (1).
	Wilson, Alex.	Gas Dept., City Chambers, GLASGOW.
	Wilson, C.	Electrical Engineer, 80, Castlenau, Barnes, London, S.W. (1).
	Wilson, D. R.	H.M. Inspector of Factories, Home Office, Whitehall, LONDON, S.W. (4).
	Wingate, M. F.	Optician, 30, Wigmore Street, London, W. (1)
	Wisé, W. C.	P. E. Chappins & Co., 85, Fleet Street, LONDON, E.C. (1).
	Wohlauer, A. A.	Consulting Electrical Engineer and Lighting and Heating Expert, 546, Fifth Avenue, NEW YORK, U.S.A. (1).
V.P.	**Wood, Sir Henry Trueman.**	Secretary of the Royal Society of Arts, John Street, Adelphi, LONDON.
C.M.	Wrightington, E. N.	Vice-President of the Boston Consolidated Gas Co., 24, West Street, BOSTON, Mass., U.S.A.
	Yates, H. J. *F.C.S., M.I.M.E.*	Chairman and Managing Director of John Wright and Eagle Range, Ltd., Essex Works, Aston, BIRMINGHAM (4).

Young, H. T.	Electrical Contractor, Messrs. Troughton & Young, 6, Park Mansions Arcade, Knightsbridge, LONDON, S.W. (1).
Young, Dr. T. Meredith	Medical Officer of Health and Chief School Medical Officer to the Cheshire County Council, West Mount, CHESTER (4).

NEW APPLICANTS FOR MEMBERSHIP IN THE SOCIETY.

The names of the following applicants for membership have been duly submitted and approved by the Council, and were read out by the Hon. Secretary for the first time at the Annual Meeting on May 21st, 1914.

Ordinary Members—

Jones, A. L.	Designer and Member Illuminating Engineering Section, Osram Lamp Dept. General Electric Co., 238, Upper Street, Islington, LONDON, N. (2).
Merz, C. H.	Consulting Engineer to Electric Power, Lighting, Railway and Tramway Undertakings in England, the Colonies and abroad, 32, Victoria Street, LONDON, S.W. (2).
Nash, Dr. E. H.	Medical Officer of Health, Town Hall, Wimbledon, LONDON (2).
Simon, H. F., *A.M.I.E.E., A.C.G.I.*	Managing Director, Electrical Installations, Ltd., 27, St. Martin's Lane, Cannon Street, E.C., 4, Wynnstay Gardens, Kensington, LONDON, W. (2).
Styles, W. E., *A.M.I.E.E., M.A.M.E.E.*	Electrical Engineer, Lecturer and Instructor Electrical Distribution and Wiring, S.W. Polytechnic, 91, Forest Drive West, Leytonstone, LONDON, N.E. (2).
Thorpe, F. W.	Fixture Designer, 18, Birley Road, Totteridge Lane, WHETSTONE (2).
Trezise, J. M. G.	Post Office, Engineering Dept. Superintending Engineer London Power District, 2, Colinette Road, Putney, LONDON, S.W. (2).
Turnbull, A. W.	Supt. Carriage and Elect. Lighting Dept., S.E. & C. Railway, 34, Greenhill Park, Harlesden, LONDON, N.W. (2).

In addition the following names have been received since the date of this meeting:—

Ball, R.	Director, Julius Sax & Co., 24A, Lordship Park, LONDON, N.
Louis, Prof. D. A.	123, Pall Mall, LONDON, S.W.
Podmore, A. E.	Gas Lighting Engineer, 34, Charles Street, Hatton Garden, LONDON, E.C.
Norden, J.	Grand Hotel des Wagons Lits, PEKIN, China, *via* Siberia.
Russell, W. R. M.	Secretary and General Manager, Holophane Ltd., 1, Trevor Square, Knightsbridge, LONDON, S.W.
Schlegel, Herr Director V.	Bamag Gesellschaft, 45 Mommsenstr. Charlottenburg, BERLIN.
Sexton, F. P. *A.R.C.S., A.M.I.E.E., A.C.P.*	Consulting Engineer, Manager to Tamesco Co., Electrical Contracting Engineer, Warwick Lodge, Hampton Wick, KINGSTON-ON-THAMES.

MEMBERS DECEASED DURING THE PAST YEAR.

We regret to record the death, during the past year, of the following members of the Society:—

Hon. Members and Vice-Presidents—

	PREECE, SIR WM. *K.C.B., F.R.S., &c.*	Consulting Electrical Engineer, Past President of the Institutions of Electrical and Civil Engineers, Penrhos, Carnarvon, NORTH WALES.
	SWAN, SIR JOSEPH *M.A., F.R.S., D.Sc., &c.*	Past President of the Institution of Electrical Engineers, &c., Overhill, Warlingham, Surrey.

Ordinary Members—

	Ernst, A. A.	Lighting Engineer, Holophane Ltd., Carteret S reet, S.W.
	Pye, T. E.	Engineer and Manager of the City of Chichester Gas Co., Clovelly, CHICHESTER.
	Watkinson, J. G.	Proprietor of J. & W. B. Smith, 15-23, Farringdon Road, LONDON, E.C.
C.M.	Weiss, M.	Chief Engineer, Zürich Gas Co., Delegate for Switzerland to the International Commission on Illumination, The Gas Works, ZURICH, Switzerland.

ILLUMINATION TESTS IN AUSTRALIA.

A correspondent writes to us from Australia giving an account of his experience in illuminating engineering in that country.

He finds, as many people in this country have done, that considerable perseverance is sometimes needed. Our correspondent was concerned in the supply of a large number of incandescent oil lamps to a railway company in Australia. He found that the usual method of test was merely to install the lamps at intervals and leave them to burn for 24 hours. Apparently no measurement of illumination or of the oil consumed was made.

He suggested that such information would be of value, but the staff regarded it as a decidedly "cranky" suggestion. Fortunately the Lighting Inspector took a more enlightened view. As an object lesson the lamps already installed were tested by the aid of a borrowed Trotter photometer. He was able to show that some lamps had an efficiency of 50 per cent. in excess of others—a result which was doubtless a revelation to those present and may induce them to believe that there is something in illumination measurements after all!

SHORT NOTES ON ILLUMINATING ENGINEERING.

THE NEED FOR SCIENTIFIC EDITORS.

In a recent number of the *Electrical Review* there is an interesting Editorial on the treatment of scientific matters in the Daily Press. Scientific men are diverted by the highly coloured and the irresponsible way in which startling inventions are announced and glorified and ideas are put forward which would never stand technical investigation for a moment.

The *Electric Review* urges that a great newspaper would do well to have a special scientific Editor who would superintend this department and make sure that such articles, while written in a popular way, were substantially correct. It is a short-sighted view to encourage sensationalism. In the long run the public would turn to the paper whose judgment in these matters was recognised to be sound and would disregard those which are notoriously inaccurate.

READY-MADE MOONLIGHT.

An interesting experiment was recently tried by the New York Edison Company at the recent Travel, Vacation, and Sportman's Show, at the Grand Central Palace (New York). The grounds were strongly illuminated by a variety of light, which was arranged to imitate moonlight as closely as possible. Indeed, it is said that this artificial moonlight "was so startlingly real that one could almost fancy hearing the night winds through the birches and occasionally the splash of a brown trout taking a moth from the surface of a near-by pool." Forty-eight thousand watts were used in the illumination of these grounds. The unusual light attracted a considerable amount of attention, and the attempt is one that might well be considered in connection with the lighting of exhibition grounds in this country.

SEEKING LIGHT.

There is a railway rule that employees working at night should be provided with plenty of lamps, said Mr. T. H. Thomas, representing the National Union of Railwaymen, at a meeting of the Railway Accidents Committee.

The Caledonian Railway Company, he said, were once apprised of the coming official visit of a Board of Trade inspector, Men were specially told off to hunt for burners and globes, and as a consequence more lights were in evidence at the depot on the particular night than ever before.—*Evening News.*

ACETYLENE IN THE ARMY.

A recent number of the *Acetylene Lighting and Welding Journal* contains some articles by Pierre Rosemberg and others on the use of acetylene in the Army.

The flashlight telegraph has been the first application. In France, Germany, Austria, the United States, and in various other countries, there already exist small apparatus, employing either ordinary burners or small burners, rendering incandescent particles of the rare earths. In the latter case a very intense light is obtained, which is increased by the employment of special reflectors.

Another application of acetylene is as follows:—At the September, 1908, manœuvres, in the vicinity of Lyons, tests were made in seeking for the wounded on the field of battle. About thirty soldiers, simulating dead and wounded, were spread at nightfall over an area of two kilometres surrounding the village of Venissieux, on uneven ground, to hide them and render more difficult the task of the ambulance corps. From previous experiments the usual means of lighting were known to be defective.

Acetylene proved to be capable of all that was expected, and two arrangements were particularly retained as being capable of rendering service; one utilised dissolved acetylene contained in a small tube carried on a man's back, and the other, not so heavy, consisted of a simple auto-generator lantern attached to the belt of the ambulance men, of which the light could be instantly eclipsed by means of a simple shutter, as with a signaller's lantern.

A striking example of the application of portable acetylene lights has also occurred in the warfare in Mexico. During one attack all the electric light cables within half a mile of the Ciudadela were put out of action and the streets were left in total darkness; but the use of acetylene flare lamps saved the victorious party from a very awkward situation. In warfare, where portability is of the utmost importance, these flare lights, capable of giving 1,000 candle-power or more, have considerable possibilities.

ACETYLENE LIGHTING OF THE PANAMA CANAL.

We hear that the Panama Canal Channel is to be marked by acetylene buoys eight feet in diameter, placed at intervals of a mile, and carrying acetylene flames giving 40 candles. By projection through the lens the rays will produce a light of 450 candles. The lights will be fed by dissolved acetylene, and it is expected that the supply will last three to seven months, according to the way they are used. All the buoys will be provided with flashing and occulting lights. The Panama Canal thus promises to be a striking example of the use of acetylene light for purposes of navigation.

STYLO-GRAPHIC PEN AND LAMP ATTACHED.

The illustration shows an ingenious device described in a recent number of *Licht und Lampe*. Most people have experienced the inconvenience of writing with a fountain pen in the dark. The illustration shows a suggested means of avoiding this by attaching just above the nib a small shielded lamp, which is connected by flex with a small pocket accumulator. The pressure of the finger on the pen operates a switch and lights up the lamp, so that the battery is only connected when the pen is in use.

ILLUMINATION IN THE COUNTRY HOME.

Some Special Uses for Light Indoors and Outdoors.

BY AN ENGINEERING CORRESPONDENT.

THE last ten years have brought with them a revolution in the lighting of country houses. At one time it was carried out exclusively by petroleum or paraffin wick lamps; indeed it may still be said that more lamps of this kind are used than ever before. But there have arisen other methods of illumination which have far greater possibilities than in the old days, and are specially adapted for rural districts where neither gas nor electricity supply is available.

The ordinary wick oil lamp, if well kept, is by no means to be despised for cottage lighting. Its mellow rays are still preferred by many people, its simplicity and portability are great recommendations. But the light that can be obtained in this way is naturally limited, and the newer incandescent oil lamps giving a thousand candle-power or more, at a much more economical rate, have special fields of utility.

Again, the person who wishes to avoid the labour involved in constantly refilling many lamps within the home can have resource to acetylene or petrol air gas, both of which have emerged from the semi-experimental state and are now very widely used in homes of moderate size and even in large country houses. The large mansion will probably have its own electric plant. Even the small householder may be tempted by the automatic petrol-driven electric sets which have recently been put on the market. There is now a wide range of choice in illuminants for the country home, and there is no reason why the illumination should not be as bright and adequate as that enjoyed by the town-dweller.

ARTIFICIAL LIGHT IN THE GARDEN.

But in this article it is not proposed to dwell on lighting within the home but rather to point out some special uses for light outside. A recent number of the *Daily Mail* contained a column devoted to the lighting of the garden—a striking instance of the attention now paid to illumination in the daily press. Few people realise what might be done by using artificial light in their gardens by night. "Has it ever struck you," says the *Daily Mail*, "that the outdoor life can be lived at home. . . . If you are staying with a friend and sitting smoking a pipe in his garden, you will probably hear him say at dusk: 'It's getting dark. Let's go in.' But that is precisely the moment when you ought *not* to go in." It is in fact, the best part of the day.

How often does one see a charmingly illuminated drawing room opening out into a completely unlighted verandah? By the cunning use of a few well-shaded or concealed lights the verandah can be made a most attractive place to sit and read in when daylight and twilight has fallen, and gives at the same time a pleasing effect when seen from the garden. A few lights distributed about the garden concealed amidst foliage, or in arbours and summer houses would quite change its appearance by night—might even make it a fairyland more delightful than in the daytime. Concealed lights on rockeries, amidst foliage or illuminated fountains, or even sunk at the foot of flower beds might be used People invite each other to inspect their beds and borders during the day. Why, in this age of abundant illumination, should the garden be unvisited during cool summer evenings?

On special occasions, garden parties, fêtes, concerts, &c., garden-illumination plays quite a conspicuous part. The wonder is that so few people get beyond candles in Chinese lanterns. It would

be by no means a difficult matter for those who have electricity, acetylene, or petrol air gas to carry wires or piping to outlets round a small garden or terrace, to achieve more ambitious decorative effects. For more occasional work, or for remote spots in large parks, &c., portable incandescent oil or acetylene lamps could be used.

Artificial Light and the Amateur Gardener.

From the standpoint of the amateur gardener light in the garden would often play a useful part. The most valuable time for planting operations is in the early morning or after a hot summer's day. Not infrequently the man who runs up to town every day from a somewhat remote district can only get back to his garden when daylight is beginning to fail; then, probably, the lady of the house insists on his presiding over the evening meal, and the opportunity for gardening is past. But with a few effective portable lights out of doors the bedding-out or planting of seedlings or the destruction of insect pests could be safely accomplished in spite of the darkness. Similarly, light led into the greenhouse or conservatory would be a valuable aid for night work or for the display of its treasures to visitors.

Artificial Lighting for Games.

Lastly, there is a most important offshoot of country house lighting that is only now beginning to receive the attention it deserves—lighting for games. We hear instances of lawns being successfully illuminated by acetylene flares, &c., for such games as quoits, bowls, &c. This is really a simple matter. All that is necessary is to illuminate the surface of the lawn and to avoid the sources dazzling the eyes of players.

But there are many games which are played under slight cover, such as fives, squash rackets, and even lawn tennis, which might readily be played by artificial light. During the last year there has been quite a boom in the erection of artificially lighted covered squash rackets courts, and there have even been artificially lighted lawn tennis courts at Dulwich, Liverpool, and elsewhere. The uncanny skill of Continental lawn tennis players in some departments of the game has been put down to their constant practice on covered courts whereas, until recently, most players in this country dropped the game during the winter. Now some clubs, like that at Liverpool, are having both lawn tennis and squash rackets covered courts installed and lighted artificially. A covered lawn tennis court is rather a large item for the owner of a country house, but the expense of fives and squash rackets courts is comparatively small, and there are quite a number of these privately owned round London.

Again, one has only to consider the number of schools in remote parts of England, almost invariably having fives and rackets courts on the premises, to see what a field for such lighting exists. It is curious that these are only infrequently artificially lighted, yet on the short winter days, when opportunities for exercise are few, these courts would be most useful in the evening.

In all such cases artificial lighting is quite feasible, and the light walls assist the satisfactory diffusion of the illumination. To light up outdoor lawn tennis courts is a more ambitious problem, but there seems no reason why even this should not be accomplished in course of time. Lighting for outdoor games is an interesting and attractive field for enterprise and it is possible that we may return to this on another occasion.

There are many other special uses for light out of doors—for meetings called at short notice, territorial camps, on board ship, for travelling shows and out-of-door concerts. The seaside parade has long been looked upon as an opportunity for spectacular lighting, and there are already some enterprising resorts that provide lights for the tents on the beach, and advertise "electrical bungalows."

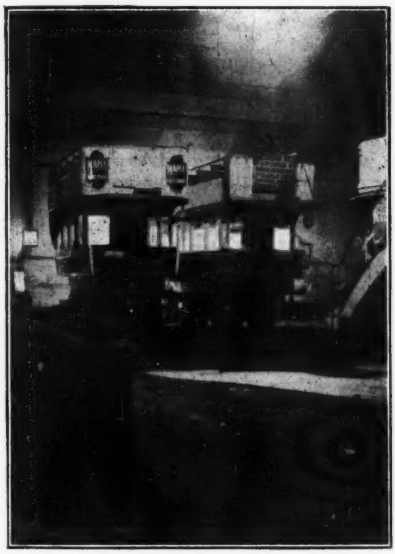
LIGHTING MOTOR-OMNIBUSES BY ELECTRICITY.

At a recent meeting of the Illuminating Engineering Society there was a discussion on the lighting of railway carriages and motor-vehicles.

During the last few years the lighting of buses in London has been revolutionised. The two views opposite were taken by night by permission of the National Steam Car Co., who have been prominent in introducing electric lighting by small voltage metal filament lamps very widely. As a rule three of these lights are spaced on the ceiling on each side of the carriage.

Small Holophane reflectors are often used in buses to concentrate the light on the seats. In other types of buses and in some taxicabs small Holophane hemispheres, fixed direct on the ceiling, are used.

There can be no question of the greater attractive power of brightly lighted vehicles by night. To those who can remember the feeble flickering light in the old horse-vehicles the brilliant illumination in the motor-buses gives quite a new aspect to the streets. Now the question is being raised, not so much how to get more light, but how to distribute this light most efficiently. Therefore the use of appropriate shades and reflectors is considered more carefully than it used to be.



Night photograph, showing some of the new buses in the yard of the National Steam Car Co. being fitted and painted.

Night photograph ; typical lightin g by tungsten lamps in prismatic glass globes.

REVIEW OF THE TECHNICAL PRESS.

THE most recently issued number of the *Transactions* of the American Illuminating Engineering Society again contains some reports of the Research Committee. One of these deals with the **Analysis of Lighting Systems.** It is suggested that besides illumination data, figures for intrinsic brilliancy, brightness of surroundings, &c., should be given. Another point is the classification of systems as "direct, indirect and semi-indirect"—not always an easy matter. The most valuable feature in this report is the list of references, which includes a number of contributions on indirect lighting.

The report on **Visual Efficiency Tests** merely discusses a number of possible criteria on eye-fatigue such as convergence, winking, examination of pupils, &c. In all these reports the Committee is content with suggesting possible lines of work for the future.

W. CHURCHILL deals with the **Danger Signals** and emphasises the value of red light, chiefly because it is almost the only colour which does not alter when viewed from a distance. Blue and purple change materially and have little "carrying power."

H. E. IVES, in the same issue, makes a somewhat radical suggestion, namely, that the light source should always be concealed; for, on physiological grounds, the object the eye is looking at should always be the brightest thing is sight. The same author has an article on "Windolite" fittings, which are designed to give shadows of a kind similar to those produced in a room by daylight. Some of these are special forms of semi-indirect units, others portable side lights.

H. LUX (*Z.f.B.*, May 30th, June 10th, 20th) has a fully illustrated serial article describing the **lighting of the stage.** Reference is made to various special contrivances, such as the Fortuny illuminated silk to give colour effects, the imitations of clouds, flames, &c.

Turning to photometry we may note an account of the work of the Reichsanstalt during the last year. The laboratory is considering the best method of comparing the half-watt lamps, the filaments of which are wound in different ways, thus giving quite distinct curves of distribution of light.

M. DEVIGNE (*Z.f.B.*, July 1st) describes an arrangement for getting polar curves from incandescent gaslights, without a mirror being necessary.

Mention should be made of the reproduction in a recent issue of the *Zeitschrift fur Beleuchtungswesen* of the series of simple recommendations on entitled "Light and Illumination: Their Use and Misuse," both the gas and electrical illustrations being shown. These were originally published in THE ILLUMINATING ENGINEER, and are reprinted by permission.

In the electrical press the half-watt lamps claim chief attention. Lux (*E.T.Z.*, May 28th) contributes an account of a series of investigations into their temperature and radiation. He finds that even these lamps only emit about six per cent. of the energy given to them, in the form of light. He suggests that 0·3 wtat per candle is about the limiting efficiency, as the melting temperature of the filament would then be approached.

Among the contributions dealing with gas lighting we may note two papers by GREBEL, abstracted in the British gas journals and an account by SCHOFIELD of **a model gas installation in a small home,** in which semi-indirect methods play a prominent part.

There is also an interesting account of the scheme of lighting Balcombe by petrol-air gas. This apparently is a case in which the area to be lighted by the petrol-air gas system is quite exceptionally large.

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Editorials. Objective Photometry (*Elec. World*, May 30th).
Definition of Photometric Units (*Elec. World*, June 20th).
Tests of the gas-filled lamp (*Elec. World*, June 20th).
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Lux, H. Moderne Theaterbeleuchtung (*Z.f.B.*, May 30th, June 10th, 20th).
"S." On the Solution of Lighting Problems (*G.W.*, June 27th).
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Photometrische Prüfungen der Physikalisch-Technischen Reichsanstalt im Jahre 1913 (*J.f.G.*, June 27th).
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Die Photometrierung verschiedenfarbiger Lichtquellen (*L.u.L.*, June 4th).
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Dézert, A. Etudes des lampes intensives ½-watt à atmosphère d'azote (*l'Electricien*, June 6th).
Ebert, F. A. Quecksilberdampflampen für photographische und Reproduktionszwecke (*Z.f.B.*, June 10th).
Lux. Untersuchungen an der Halbwatt lampe (*E.T.Z.*, May 28th).
Die Omega-Spirallampe (*Z.f.B.*, June 20th).
Ueber Tageslichtlampen (*L.u.L.*, May 21st).
Elektrische Licht für Arbeiterwohnungen (*E.T.Z.*, June 18th).

Gas, Oil, and Acetylene Lighting.

Ahrens, F. Intensivlampen für die Glühlichtbeleuchtung mit verdampften flüssigen Brennstoffen (*Z.f.B.*, May 30th, June 10th, 20th).
Grebel. The Best Heights for Public Lamps (*G.W.*, June 27th).
Public Lighting of Paris (*J.G.L.*, July 7th).
Pradal. Neue Gaszünder (*Z.f B.*, July 1st).
Schofield, T. Home Lighting as shown in a Model Apartment (*Am. Gaslight Jour.*, May 25th).
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CONTRACTIONS USED.

E.T.Z.—*Elektrotechnische Zeitschrift.*
G.W.—*Gas World.*
J.f.G.—*Journal fur Gasbeleuchtung.*
J.G.L.—*Journal of Gaslighting.*
T.I.E.S.—*Transactions of the Illuminating Engineering Society* (*U.S.A.*).
Z.f.B.—*Zeitschrift für Beleuchtungswesen.*
L.ü.L.—*Licht und Lampe.*

EIGHTH INTERNATIONAL ACETYLENE CONGRESS.

WE note that the Eighth International Congress on Acetylene Lighting and Welding is to take place in Paris from October 7th–18th, and that an International Exhibition will take place simultaneously. The Congress and Exhibition will receive the patronage of the Ministries of Commerce, the Navy, War, Agriculture, Public Works, Education, and the Colonies. The Exhibition will cover an area of 5,000 square metres, and many novel applications of acetylene will be on view.

Those interested should apply to the Commissariat-General, 104, Boulevard de Clichy, Paris.

ACETYLENE FLARES AT THE PANTHEON, PARIS.

Messrs. Imperial Light Ltd. (123, Victoria Street, London, S W.) send us an interesting account of the lighting of the Pantheon on the occasion of the bicentenary of Jean Jacques Rousseau last year. Arrangements had been made for 1,500 musicians and choristers to assemble and rehearse the music, and it was only gradually that it dawned on people that it would be difficult to hold such an entertainment in the evening owing to the fact that neither gas nor electricity has been led into the building.

Eventually it occurred to the Director that the emergency lighting could be provided by means of acetylene, and in a few hours one dozen portable Imperial Flares were installed. The proceedings were followed by an audience of 1,500, and the musicians had ample light by which to read their scores.

A view of the Pantheon in Paris where special lighting by a dozen Imperial acetylene flares were used on the occasion of the centenary of Jean Jacques Rousseau (July 31st, 1912).

(*Photo taken by the light of the acetylene flares alone.*)

The photograph reproduced above was taken after the performance entirely by the light of the acetylene flares, and gives a good idea of the complete diffusion of the illumination.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

THE LIGHTING OF A WEST-END TEA ROOM.

THE illustration below shows a view of the well-known Tea Room of Messrs. Stewart & Co. (50, Old Bond Street, London, W.). A tea room of this kind, situated in the entertainment and shopping area of London, requires a bright and cheerful illumination; the value on the tables being in this case 5½–11 ft.-c. in the basement and 5–8 ft.-c. on the first floor. Throughout these premises Holophane reflectors and 32-watt pip-obscured tungsten lamps are used, most of the lighting being accomplished by 3-light chandeliers.

Besides the basement and the afternoon tea room on the first floor, the front shop is also lighted in this way.

A view of the Tea Room of Messrs. Stewart & Co., Old Bond St. (basement), lighted by Tungsten Lamps in Holophane Reflectors.

(*Photo taken entirely by artificial light.*)

LIGHTING OF THE UNDERGROUND NEW CHARING CROSS STATION (EMBANKMENT).

LONDONERS are by now become familiar with the new underground station at Charing Cross (Embankment), which forms such a convenient junction for the Underground Railway, the Charing Cross, Highgate and Hampstead Tube, and the Bakerloo Tube. Whereas, until recently, it was necessary to leave the Underground station and make a detour through the streets to reach either of the two tubes, one can now enter them direct by means of the series of moving stairways.

Natural photograph by artificial light. *Lumina Bureau Photographic Dept.*

Lighting of the platform of the new Charing Cross (Embankment) Station.

A few words may be said as to the lighting of this new station, illustrated in the two photographs taken by the kind permission of the Underground Railway Co. Fig. 1 shows the method

of lighting the platform of the Charing Cross and Hampstead Tube terminus. This is lighted by metal filament lamps in Superlux globes and Benjamin rings, the units being spaced at intervals of about 25 feet. A test showed that an illumination on the platform from 0·8—1·2 ft.-candles were provided between the units—a figure considerably above the 0·25 ft.-candles suggested as the minimum for main station platforms. The photograph gives a very good idea of the soft and restful conditions.

The second photograph (Fig. 2) shows the entrance to one of the moving stairways. The lighting of this staircase is decidedly good, the lamps are screened by plates across the ceiling so as to be invisible to the descending passengers. The space adjacent to the entrance to the stairway is also illuminated by 100-watt metal filament lamps in Superlux globes.

Natural photograph by artificial light. *Lumina Bureau Photographic Dept.*

Entrance to one of the moving stairways at the new Charing Cross (Embankment) Station.

For some of the information used in this article we are indebted to the courtesy of the General Electric Co., Ltd.

THE LIGHTING OF SQUASH RACKET COURTS.

Some time ago we referred to the lighting of Squash Racket Courts*—quite an interesting problem for the illuminating engineer. There has recently been a "boom" in covered courts of this kind. The essential point in this, as in most other ball games, is to avoid any inconvenience due to glare, and to keep the lights as far as possible out of the direct range of vision. In addition, the light must be thoroughly diffused throughout the room so that all the walls are well lighted.

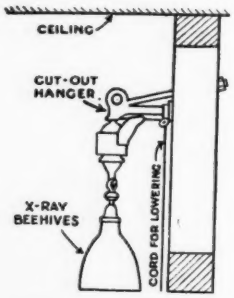


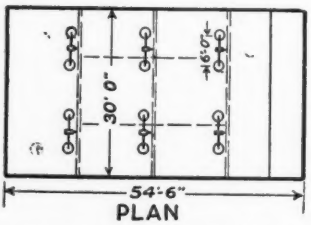
Diagram showing how the X-ray units are suspended on special cut-out hangers. This enables each pair to be lowered for cleaning or renewals.

The illustration shows a method adopted by the **British Thomson-Houston Company,** and described in a recent number of *Mazda House News*. The installation consists of twelve X-ray (Beehive type) silver glass reflectors, each containing one 250-watt clear Mazda lamp. The dimensions of the room are 54½ ft. by 30 ft.; ceiling height, 36 ft.

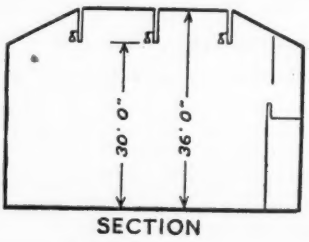
As will be seen from the illustration the lights are invisible to the players unless they look directly upwards. Fortunately this game is played with a small *black* ball and the background is *white*. This considerably simplifies the task of the lighting engineer, for the white walls diffuse the light in all directions, giving a very even illumination and making it easy for the players to distinguish a rapidly moving ball.

* Illum. Eng., Lond., Vol. iv., 1911, p. 178.

Night photograph taken from the back of the court. Lamps are completely concealed from the eyes.



Showing method of distributing the lights.



INDEX, August, 1914.

		PAGE
Editorial	L. GASTER	379
Eye Problem in the Schools, The	DR. A. J. LADD	386
German Illuminating Engineering Society, Notes on Proceedings		385
Harmful Radiations, Protection of the Eye from		383
Illuminating Engineering Society— (Founded in London, 1909.)		
Summary of Work done		**389**
List of Papers read, 1909-1914		**391**
„ „ Committees		**394**
„ „ Members		**395**
Illuminating Engineering, Short Notes on		419
Lighting of Statues	J. ECK	387
Nomenclature and Definitions of Photometric Magnitudes and Units	LORD RAYLEIGH	388
Review of the Technical Press		424
Topical and Industrial Section		427

THE METEOR PATENT ELECTRIC SIGNS.

An extremely interesting and new form of illuminated sign has been introduced by the **Meteor Manufacturing Co.** (72—74, Gray's Inn Road, London, W.C.). The lettering is engraved in white on the back of a glass plate illuminated from above or below by a completely concealed tubular lamp. The rays of light pass into the glass through its edge and remain entirely totally internally reflected from the faces within the glass, no light escaping through the surface. The glass thus acts like a condenser. The white letters are brilliantly illuminated and stand out in a positively uncanny manner. They are also readily visible by day.

A feature is the small space occupied by the sign, as compared with those of the box type. We understand that it has already found quite a number of special applications, besides the ordinary uses of electric signs. For example, it has been employed with lamps consuming only two watts for the number plates of motor cars. The illustration shows a compact form of the sign that has been installed on the "Aquitania" by the Cunard Steamship Co. An illustrated booklet issued by the Meteor Company illustrates their suggested use to indicate the position of the boats in the event of a disaster. The desirability of effective notice boards on these "floating hotels" is evident. Panics are not infrequently accentuated by the fact that many passengers do not know their way about the ship.

BLANCHARD LAMPS AT THE SOUTH POLE.

FROM **Blanchard Lights, Ltd.** (151, Farringdon Road, E.C.) we understand that Sir Ernest Shackleton's expedition to the polar regions will be exceptionally well equipped as regards artificial light. In the long winter polar days when daylight fails this is a vital matter. For camp work some form of powerful but self-contained illuminant is essential. Accordingly the expedition will be equipped with a number of Blanchard incandescent lamps burning paraffin vapour.

Another recent application of these lamps was in connection with the Welsh Eisteddfod Festival, which takes place in the open in a different spot each year.

SIEMENS' CONTRACTS.

Messrs. Siemens Bros. Dynamo Works, Ltd. (Tyssen St., Dalston), inform us that they have secured the following contracts :—

Bristol Tramways and Carriage Co., Ltd. (carbon filament lamps), York Corporation (Carbon filament, Tantalum, and Radiator lamps), Great Northern Railway (Carbon filament lamps and Station Lighting Reflectors).

FALK, STADELMANN & CO., LTD.

We have received a copy of List No. 384 issued by the above-named firm dealing with electric lanterns for half-watt lamps and embracing designs suitable for shop fronts, large interiors, and for street and outside lighting.

We are asked to state that a copy will be sent free to any contractor interested who applies to the Company at 83–87, Farringdon Road, London, E.C.

VERITY'S (31, King Street, Covent Garden, London, W.C.) send us recent list of several " Aston " specialities, including the Aston Verilite candles.

We have also received particulars of new Aston attachment as used in with indirect fittings in the premises of the Asiatic Petroleum Co., Ltd. To this we hope to refer in detail shortly.

EDISON & SWAN UNITED ELECTRIC LIGHT CO., LTD.

Lists of Ediswan Fans, Electric Heating and Cooking apparatus, Telephones, Accessories, &c.

We note that the Glasgow Royal Hospital, opened by the King last week, is lighted throughout with Royal Ediswan lamps, nearly 2,000 being in use.

B.T.H. NEW TELEPHONE NUMBER.

We are asked by the **British Thomson-Houston Company** to state that, for the convenience of their customers and themselves, they have had two additional lines installed in their private telephone exchange at Mazda House, 77, Upper Thames Street, London, E.C. The telephone number has also been changed, and, instead of ringing up Bank 5561-2-3 as heretofore, readers should note that all future calls must be made to one or other of the following numbers : Central 10434, 10435, 10436, 10437, 10438.

PROGRESS IN THE HALF-WATT LAMP.

As we go to press we receive particulars of a substantial reduction in the prices of half-watt lamps that is being made by all the leading companies.

In addition, it is evident that before long we shall be able to obtain half-watt lamps of considerably lower wattage than at present. Already one can get 100-watt lamps for use on 50-volt circuits.

Another novelty is the issue of lamps with filaments wound specially for projection purposes, and intended for cinematograph work. Those interested should apply for fuller particulars to **Messrs. Siemens Bros. Dynamo Works, Ltd.**, the **General Electric Co., Ltd.**, the **British Thomson-Houston Co., Ltd.**, and the **Edison & Swan United Electric Light Co., Ltd.**, all of whom are issuing lists summarising these developments.

9

The ILLUMINATING ENGINEER

Edited by LEON · GASTER

ELECTRICITY · ACETYLENE · OIL · GAS

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EDITORIAL.

The Great War.

WHEN our last editorial was written there were already rumours of war. People had become aware that a cloud was overshadowing Europe and were anxiously wondering what nations would be involved. It seemed incredible that in such a short time the many threads of peaceful interest between nations would be severed, and that a few days would see the commencement of the vastest conflict of modern times. Science, it is rightly said, has no geographical boundaries. During recent years it has done much to draw the nations nearer together, and we had come to hope that its pacific influence would prevail.

Yet the incredible has happened. Already we are experiencing the devastations of battle and millions of men are engaged in the work of destruction. Many international movements have been temporarily brought to naught by the warring of nations. We can only hope that before long friendly intercourse will be resumed.

There is no need to dwell upon the present unparalleled financial situation. Many businesses are closely interlinked with Continental countries and any disturbance there is bound to react in England. In times like these, when contact with abroad is abruptly severed, we realise, perhaps more forcibly than we would otherwise have done how dependent we are on foreign supplies. Whatever be the upshot of the present struggle this country should take the opportunity to place itself in a more independent position.

At the present moment a great deal is being said about "capturing Germany's trade." We wish to point out, in all earnest, that our business is to organise *quietly and effectively* and not to shout aloud our plans, thereby giving our rivals an intimation of what we propose doing. Contrast the secrecy and efficiency with which our expeditionary force has been landed in France with the manner in which this industrial campaign is being handled! There is admittedly a great deal of talk—and much of it useless talk. This is not the way to capture trade.

We should also like to make it clear that we do not encourage the effort made in certain circles to extend our trade merely as a measure of offence against other countries. A business campaign waged only with the intention of damaging opponents, and based on an unsubstantial foundation is likely to come to grief in the long run. The present situation reveals defects in our industrial armour that might otherwise not have been recognised, and affords an opportunity of putting things right. We fully believe that circumstances have provided this country with a great opportunity. It is of the utmost importance that, while other nations are industrially helpless, we should keep our trade going and make wise provision for the future.

Our first duty must be to keep our shores free from invasion. At the same time we must study how to keep business going as usual, and even to improve the commercial situation. We believe that all things which are absolutely necessary either for daily life or for national defence should be capable of being manufactured at home. It does not follow that in normal times the entire trade in such commodities would be supplied by home manufacture. Healthy competition in these circumstances is highly beneficial. But there are admittedly many industries that are carried on *exclusively* abroad and might well be undertaken over here.

But in most cases this extension of industry can only be accomplished by systematic enquiry and very hard work. Let us now consider some of the chief difficulties to be encountered. There are many

trades which require special raw materials and skilled operators, technical education of a high order, and machinery and appliances covered by foreign patents—all items which can only be acquired by degrees.

An important factor in Germany's commercial success is the existence of greater banking facilities for industrial concerns. The banks in this country are rightly praised for the calm way in which they have faced the situation and the promptness with which they took precautions to avoid a panic. Yet it is evident that their caution in many cases tends to restrict extensions of business. It may well be urged that they cannot, without departing entirely from their ordinary procedure and recognised functions, lend large sums for industrial enterprises. We should, therefore, like to see steps taken towards the creation of industrial banks, on somewhat similar lines to those existing in Germany but adapted to English conditions. These Continental banks have at their disposal technical and legal advisers who investigate the merits of each proposition and naturally exercise a very careful supervision over the concerns they decide to suport. In this country the starting of a large business usually involves an appeal for money to the general public. Sometimes the courage of the private investor is justified ; but he has really little security and the history of many transient booms and subsequent collapses shows how often his money is wasted on enterprises which would not stand serious investigation by a competent business man. It would in most cases be far better for the private investor to put his money at the disposal of an industrial bank whose judgment of commercial enterprises is probably better than his own.

In this country the question whether a new industrial departure was commercially feasible and deserving of such support might well come under the consideration of the Board of Trade,. The best plan would be to appoint competent independent authorities with full powers to conduct exhaustive enquiry into each section, collect the necessary data and send in a Report to the Board of Trade, embodying suggestions for the guidance of those engaged in this branch of industry. Among the matters studied might be included : (*a*) the conditions as regards supply of raw materials, (*b*) the practicability of introducing new processes of manufacture, (*c*) the patent situation, (*d*) the amount of skilled labour available, (*e*) the general prospects of the continuance of present industries and the probability of extensions of trade being retained on a remunerative basis.

Only by a deliberate and sober survey of the situation can any lasting progress be made. Feverish advertisement and irresponsible clamour on the subject of capturing trade will accomplish very little.

The War and the Lighting Industry.

It so happens that the experience of the lighting industry bears out very strikingly the need for enquiries of the kind suggested above. And our Industrial Section this month contains a series of letters from various firms bearing on the situation.

On the whole the replies are reassuring but it is common knowledge that a large proportion of the lamps used within recent years have been wholly or partly manufactured abroad, and it stands to reason that the sudden cessation of this supply will not be made good in a day. Similar considerations apply to the supply of carbons for arc lamps. The number of carbons manufactured in this country is comparatively small. By far the greater portion of our supply comes from abroad. The same applies to many special materials and appliances used in the lighting industry, such as the chemicals, ornamental glassware, etc.

In the gas industry the problems are very similar. Many parts used in lamps and burners, formerly manufactured abroad, must now be made at home. The danger of a shortage of mantles must also be guarded against, and provision made to secure the necessary chemicals for manufacture. Within the last few years an exceedingly rich deposit of monazite sand has been discovered in Travancore, India, and from enquiries which we have made, we believe we are correct in saying that there is nothing to prevent British firms obtaining material from this source if they so desire. A more formidable difficulty appears to be that the extraction of thoria and the other chemical materials needed for mantle manufacture has not been energetically taken up in this country.

Meantime readers will observe (see p. 464) that the South Metropolitan Gas Co. has in hand a substantial stock of thorium nitrate accumulated in times gone by, and we understand that both they and other gas companies have ample supplies of mantles for present needs.

Turning to other sections of the lighting industry we find that the prospects of business are hopeful. Carbide can be obtained from Italy, Norway and Sweden, and a certain amount, which could doubtless be increased if necessary, is made in this country. Petrol and paraffin are available and likely to remain so.

Taking a general survey of the situation it is reasonable to hope that the means of obtaining artificial light will be available for some time to come and that the industry is prepared to adapt itself to the present conditions until the war clouds roll away and better times arrive.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

THE MEASUREMENT OF BRIGHTNESS.

BY AN ENGINEERING CORRESPONDENT.

A CONTRIBUTION by Dr. H. E. Ives on this subject is to be found in a recent number of the Transactions of the American Illuminating Engineering Society (U.S.A.)*.

During the last few years the idea of measuring illumination has become familiar. But it is now recognised as useful to be able to measure the actual brightness of objects. For example it is desirable to know the brightness of illuminated friezes and ceilings, ornamental globes, &c. It is well-known that some authorities consider that the illuminating sources in a room should not have a brightness exceeding that of the average white sky (2½ candles per square inch). Others, again, point out that glare is largely a matter of contrast and that we ought therefore to specify the limiting ratio between the brightness of an object and its surroundings. From the artistic standpoint it is also well to have some idea what this ratio should be. Attempts have been made to specify the desirable relative brightness of walls and ceilings and the comparative values of the ceiling and a semi-indirect bowl suspended under it, in order to give a pleasing effect. To determine all these factors we must have methods of measurement.

* Vol. ix., 1914, No. 3, p. 183.

The chief difficulty in such measurements is that the range of brightness is commonly so large. Thus Dr. Ives points out that the ratio of brightness of a tungsten filament to a white paper illuminated with an intensity of 2 ft.-candles is as much as 258,000 to 1. In general the range is greater in an interior artificially lighted than in one that receives natural light. Thus Dr. Cobb mentions that in a room lighted by daylight the ratio between the brightest and darkest objects was 400 : 1; while by artificial light it was as much as 100,000,000 to 1. As an illustration of the range of brightness in an artificially lighted room we may take Fig. 1, in which Dr. Ives has indicated by numbers the brightness of various objects in candles per square centimetre.

The methods used in measuring brightness depend on the nature of the object viewed. There are, says Dr. Ives, three chief methods employed according as the brightness is high, medium, or low. As an instance of great brightness we may take incandescent filaments where the brightness is of the order of hundreds of candles per square centimetre; as instances of medium brightness we may take light sources surrounded by somewhat dense diffusing globes, (*e.g.*, opal glass) the intrinsic brillancy of which

may be 0·25 candles per square centimetre. As illustrations of low brightness we may take the illuminated walls in a room in an ordinary lighting installation where 0·0005 candle-power per square centimetre or less, is common.

In measuring the brightness of such objects as incandescent filaments the best plan is to determine the total candle-power and to divide this by the measured superficial area of the filament. Having thus obtained the brightness of a standard filament under specified electrical conditions we can compare the brightness of others by super-imposing them on its image and then varying the current of the standard filament until both appear equally bright.

In the case of a diffusing globe it is usually most convenient to screen off all except a certain small measured area and to determine the candle-power of this element. As a rule the brightness of such a globe is too high to be measured directly.

This leads us to the third method—direct observation. During the recent years there has sprung up a new form of photometer adapted for measurements of "surface brightness."

When such instruments are used to measure illumination the usual plan is to place a standard matt white surface at the place where the illumination is to be measured and to observe this from a distance. This standard surface is viewed through an aperture in the photometric screen and the brightness of the latter is adjusted to equality with it. This standard surface is always used in calibrating the instrument for illumination.

When the instrument is used to measure brightness of surrounding objects all that is necessary is to observe them through the aperture in just the same manner as the standard screen. (It is important to notice that the apparent brightness of an object is the same irrespective of the

FIG. 1.—View of an artificially lighted interior showing brightness (in candles per square centimetre) of various objects. (Dr. H. E. Ives.)

distance from which it is observed. For the amount of light entering the eye from the object is inversely as the square of its distance away, but the area of the retinal image is also decreased in the same proportion; consequently the intrinsic brightness of the image in the eye remains the same whatever the distance of the object may be.)

It is not unusual to state the brightness of a surface in "candles per square inch" (the so-called "primary" method) when it emits its own light and its brightness is comparatively high; and to give the brightness in "foot-candles" (the so-called "secondary" method) when the object is not self-luminous, but is visible only by reflected light. When we say that an object has a brightness of so many "foot-candles," we mean that it appears as bright as a dead white surface of reflecting power 100 per cent. would do, if it received an illumination of this value.

According to this method if E denote the illumination received, m the diffuse reflecting power of the surface illuminated, b, the brightness of the surface $=m.E$.

"Brightness" is thus a quantity which depends on the nature of the reflecting surface whereas "Illumination" has to do with the amount of light impinging on a unit area of the surface only.

It is obvious that if two surfaces are set up side by side, receiving the same illumination, and the brightness of each is observed in turn, the ratio of these readings gives us their *relative* reflecting power. But we must have available a surface whose *absolute* reflecting power is known in order to ascertain this quantity for other surfaces.

From a commercial standpoint it is fairly correct to assume that the reading of any surface-brightness photometer, calibrated for illumination, gives at once the brightness of an observed object, as defined above. But it is not *absolutely correct* because the white illuminated surface used in calibrating the instrument does not reflect 100 per cent. of light, but more probably about 80—90 per cent. Consequently the absolute reflecting power of the screen used with the photometer should be taken into account when it is used for brightness measurements. If two observers used screens in their instruments of different reflecting power the photometer might read *illumination* quite correctly but would not give concordant as regards surface brightness.

There are certain cases in which this method of expressing brightness is very convenient. For example in daylight calculations. It can be shown that the horizontal illumination received from a uniformly illuminated white sky (the total unrestricted daylight illumination) is equal to the brightness of that sky expressed in foot-candles. This fact is very convenient when one is relating the outdoor illumination to the illumination at any point in a room. It also enables us to make use of two alternative methods of measurement, either to determine the brightness of the sky by direct observation (pointing the instrument at the sky) or to lay the test-screen down horizontally and measure the actual unrestricted illumination due to the sky. Theoretically, both methods should give the same result, but as the sky is rarely of exactly uniform brightness this may not be the case in practice. In general, a measurement of the total illumination is probably the more accurate method.

From a scientific standpoint, however, there are objections to the "secondary" method of expressing brightness. It involves the idea of a perfectly matt white surface reflecting 100 per cent. of light—always a difficult conception—and renders necessary a determination of the absolute reflecting power of the surface used with the photometer. Moreover, when dealing with such surfaces as the sky which emits light, it is not strictly correct to speak of foot-candles, which should be applied only to illumination. Most authorities, therefore, seem to consider that it is preferable to express brightness in terms of candles per unit of area. For a surface may be regarded as having a certain candle-power per unit of area, irrespective of the fact of its being luminous like a flame, or luminous merely in virtue of reflected light.

At this stage it may be useful to give the formula connecting the brightness expressed in both ways. Although the relation was determined many years ago it is not very generally known. Since the

most ready method, in determining the brightness of illuminated ceilings, screens, etc., is to obtain results in terms of foot-candles, it is useful to know how to convert these values into candle-power per square foot.

The relation is as follows :—

B, the brightness in candles per square foot $= b$ (the brightness in foot-candles)$/\pi = m.E/\pi$.

The equation is readily proved as follows :—

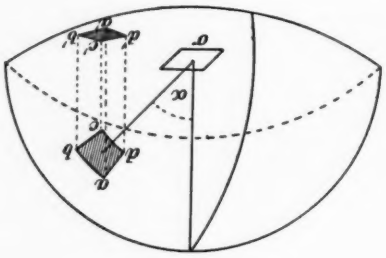


FIG. 2.

Let σ be a unit area receiving an intensity of illumination E. Then the amount of light received by the unit area is E lumens and the amount of light emitted by it is mE lumens (m being the diffuse reflecting power as mentioned above). And since we are dealing with a unit area mE is also equal to the brightness, b, in foot-candles.

Let the candle-power of this area be I, which is numerically equal to the brightness B (candles per unit area). Now consider a small area *abcd* on the surface of a hemisphere of radius r surrounding the unit area. The intensity of illumination on this area will be $I \cos \alpha / r^2$, α being the angle of the direction of rays with a normal to the surface σ. The total light received by the area is thus $I/r^2 \times$ area, *abcd*, $\times \cos \alpha$. The total light received by the hemisphere is equal to the sum of the light received by all such areas as *abcd* that is, $\frac{I}{r^2} \Sigma\, abcd, \cos \alpha$. But it will be observed that area *abcd*. $\cos \alpha$ is equal to the projection $a'b'c'd'$ of this area on the semi-circle in whose plane σ rests, and that, $\Sigma\, abcd \cos \alpha = \pi r^2$.

We have therefore :

Total light emitted by $I/r^2 \times \pi r^2 = \pi I$.

Whence the relation

$$B = \frac{b}{\pi} = \frac{mE}{\pi}.$$

Therefore when the brightness of any surface has been measured in the manner described above and obtained in foot-candles, it is only necessary to divide the result by π in order to get its value in candles per square foot. This is the natural method of obtaining the illuminating power of friezes, ceilings, etc. ; it was for example used by Mr. Trotter in his calculation of the effect of the frieze in the theatre of the Institution of Civil Engineers.*

It will be noted that if such a surface is observed through a surface-brightness photometer we do not need to know its reflecting power—a point of some consequence in the case of distant inaccessible objects. All we *do* need to know is the reflecting power of the screen used to calibrate the instrument. On the other hand if we know the absolute reflecting power of the surface studied it is only necessary to measure the illumination received by it, and we can then dispense with a knowledge of the reflecting power of the photometer-screen.

One other point may be raised. The above relation applies rigidly to surfaces of a matt character, for which the cosine law is true. But what about illuminated semi-matt metallic surfaces, opal glass illuminated from behind, &c.—surfaces whose candle-power in any direction is not proportional to the cosine of the angle at which they are viewed ? Can we, in such cases, point our instrument at the surface and determine the candle-power by square foot by means of the above relation ?

It would appear that it is quite justifiable to do so. For, we might replace the luminous surface examined by another one, having the same apparent brightness, but obeying the cosine law. The candle-power per square inch *in the particular direction* would be unaltered, and the same relation would apply.

* Illum. Eng., Lond., Vol. vii., No. 5, 1914, p. 231.

THE LIGHTING OF FACTORIES.

Some Notes on the Report (for the year 1913) of H.M. Chief Inspector of Factories.

BESIDE the references to lighting in this Report there are many points of general interest. Special reference may be made to the Museum of Safety Appliances, mentioned in previous reports and now actually in course of erection. It is stated :—

"After delays due to circumstances beyond the control of the Home Office, the Museum of Safety Appliances is now being erected on a site in Horseferry Road, and should be completed early next year. The scheme includes exhibits of approved appliances for the prevention of industrial accidents and disease in mining as well as processes under the Factory Acts; these appliances will be shown in conjunction with actual working machines in motion as far as practicable, and supplemented by models, photographs, &c., where necessary."

At the instance of the Home Office, special research with regard to the measurement of fatigue in industrial work was commenced by Professor Kent at the Bristol University in 1913, and is still in progress.

We now give *in extenso* the section of the Divisional Report dealing with lighting :—

Lighting.—The investigations by the Departmental Committee are still in progress, and this subject must therefore be regarded as being to some extent *sub judice*. While it has not been possible on this account for Inspectors to take any very active steps, the question has not been entirely lost sight of. It formed one of the subjects of discussion at the Iron-foundries conference, where proposals were put forward for standardising both natural and artificial lighting. As regards the former it was suggested that there ought to be a minimum relation between window and floor area, and a proportion of 1 : 4 was proposed. A special investigation into the artificial lighting of foundries had been carried out by Mr. D. R. Wilson and a memorandum giving the resuts of his inquiries was published in last year's reports. It seemed possible from the data collected to draw a fairly clear line between efficient and non-efficient lighting, and his conclusions were therefore embodied in a proposal that :—

> "No foundry shall be deemed to be adequately lighted unless the illumination intensity, measured on a horizontal plane 1 foot above the floor level, does not fall below 0.3-0.4 foot candles over any part in which work is being carried on, or over which any person is liable to pass."

Both these proposals were discussed at considerable length, but consideration of them was ultimately postponed until the second meeting of the conference. In the meanwhile the announcement was made of the appointment of the Departmental Committee, and the employers at the second meeting intimated that though the question had been carefully considered since the previous meeting, they thought it inadvisable to continue discussion in view of the wider investigation that would be undertaken by the Committee. No definite results were arrived at, therefore; at the same time there was a general agreement amongst those present as to the importance of good lighting. It is important from three points of view. First from that of safety : it is well-nigh impossible to produce statistics to show the effect of lighting on the accident rate, but the proposition that a well-lighted foundry is a safer place to work in than a badly lighted one was generally accepted at the conference. Secondly, as regards output : it could hardly be disputed that more work and better work is produced under good lighting conditions, and the following

quotation is pertinent to this aspect of the case :—

Mr. H. J. Wilson (*Glasgow*).—There is no doubt whatever that a highly intelligent interest is being taken in improved lighting of industrial premises. I am always told that improvement in lighting pays the manufacturer, and as this becomes recognised little encouragement is necessary to persuade employers to adopt an efficient system of illumination. Two large shipbuilding firms have entirely remodelled their lighting at considerable cost both for inside and outside work.

Finally as regards its effect upon the comfort and eyesight of the workers—and it is on this point that guidance is perhaps most needed from the Committee—one rather startling case is quoted by Mr. Jackson :—

Mr. Solloway (*Manchester*).—A particularly bad case of apparent eyestrain through defective lighting was noticed in a cotton-reeling workshop. This was partly underground and had windows on one side only. Except on very bright days gas was used for lighting nearly continuously, and exactly 50 per cent. of the workers employed on the row of frames furthest from the window wore glasses, whilst on the row nearest the window only 5 per cent. wore them. The occupier treated the fact as a mere coincidence, but it appeared a possible case of cause and effect.

This case was brought to the notice of the Lighting Committee. Two other quotations may also be added in which the Inpsectors describe certain methods of lighting which appeared to give particularly successful results.

Mr. Broadhead (*Glasgow*).—At a recent visit to a large factory I was much struck by the comparison afforded by three methods of lighting in use there, viz. :—high pressure gas, electric light (metal filament lamps), and high-pressure oil lamps, all of them good illuminants. The oil lamps, while quite as good as the others, gave, I think, the softest light, was less trying to the eyes, and was at the same time the cheapest. The necessary pressure was produced by a hand pump, which was only started one hour before darkness and was worked for two hours altogether. Mechanical power not being required, this form of lighting would be especially suitable for workshops.

Mr. Shaxby (*Yeovil*).—An engineer's drawing office provided a demonstration of the great value of appropriate shades. All but one of the pendant electric bulbs happened to be fitted with more or less parabolic metal shades (painted green outside and " aluminium " inside). The glare from the unprotected bulb was very noticeable amongst the other lights, whilst the board beneath it appeared to be only about half as brightly lit as the boards under the shaded bulbs.

Lighting is referred to incidentally in several other portions of the Report. For example on p. 79 there are some general comments on the subject, and the remarks of two Lady Inspectors are quoted on the subject :—

An increasing number of complaints is received in several Divisions with regard to defective natural lighting and badly adjusted or otherwise defective artificial lighting. The Inspectors do what they can to secure improvements, though as the matter is outside the Factory Act in general no contravention notice or other official action is as yet practicable. Two bad cases concerning women compositors in different parts of the Kingdom are specially reported; in both artificial lighting was required during the greater part of the day, and in only one of these instances is a remedy being supplied by removal to better premises. In the other case, when the women learned that lighting is still outside the Factory Act so far as their case is concerned, they exclaimed to the Senior Lady Inspector, Miss Squire, " but this is the most important thing of all to us."

Miss Squire.—Badly adjusted light which hurts the eyes was found in boot factories where out of nine visited in one town four had the sewing machine rooms provided with ordinary fish tail burners on a jointed bracket at every machine—these unshaded were on a level with the workers' eyes and close to the face. The girls complained that

the light was poor and had a smarting effect upon the eyes. The adaptation of artificial lighting to the requirements of the work receives in general very little attention but I find that a desire for some guidance in the matter is growing among employers and managers. One difficulty is that of procuring any shade for the large metal filament electric lamps now so largely used. The glare of these in the eyes of machine operatives in all classes of factories is a troublesome accompaniment of the work and one finds much makeshift screening by workers where such individual effort is permitted.

Miss Meiklejohn.—A few of the larger firms have taken the matter up, but in the average workroom you find either strong incandescent burners or unobscured and often unshaded electric light. One large firm has adopted indirect lighting. They say that the result is good, the light more nearly resembling natural light. I believe, however, it is more expensive and a stronger light is required. Another large firm has introduced inverted metal troughs, burnished inside, which come well down over the electric lights. The results appeared excellent, and I am told there is a great saving in electric light, as compared with the old method. The same firm have introduced a very good lamp for sewing machines. This is a small carbon lamp fixed to and connected with the small motor which drives the machine. It has a reflector above and throws the light on the needle.

Again on p. 112 reference is made to the need for good illumination in printing works. It is worthy of note that in a number of instances stress is laid on the use of adequate shaping appliances and the unsatisfactory lighting effect of shallow reflectors used with the metallic filament lamps :—

In compositors' rooms the lighting by day is generally good, but the arrangements for artificial lighting are not well adapted to the requirements. The lights were frequently placed so that the type cases were partly in shadow and the glare was full on the workers' eyes. The latter was especially noticeable where electric light was used. The larger lamps which have more recently come into general use were provided only with the shallow shade which was suitable for the small lamp formerly used, but it is quite inadequate for the larger ones.

LIVING CONDITIONS IN BRITISH SHIPS.

THE living conditions of seamen in the British Mercantile Marine were discussed at a meeting of the Port Sanitary Authorities in July. Dr. Collinbridge, of Pembury, said that these conditions left much to be desired. "The sailor is housed in a dark, damp, over-crowded, ill-ventilated forecastle, his food is of the worst description, and the cooking is usually beyond description."

Dr. Herbert Williams (Medical Officer, Port of London) remarked that "the conditions under which seamen live on many vessels can only be compared with those under which cave-dwellers lived in prehistoric times."

There seems in fact to have been practical unanimity that the present conditions are badly in need of reform. If the forecastle is over-crowded and ill-ventilated it is highly probable that in many cases it is also ill-lighted. Seeing that such leisure as a crew possess is usually spent down below where there is little daylight available, the artificial illumination is a matter of consequence. No doubt medical officers, while insisting on proper conditions in other respects, will keep the requirements as regards lighting in mind.

THE PROTECTION OF EYESIGHT.

THE following is an interesting notice issued by the Industrial Museum at Munich. It is addressed to workers, and summarises the precautions to be taken in order to avoid injury to the eyes. Now that so much is being said on the preservation of eyesight and a great movement has been started for the care of the blind, the publication is timely, and we give in what follows a translation (slightly abridged) of the suggestions contained therein :—

WORKERS! PROTECT YOUR EYES.

For every industrial worker, for every human being, in fact, a sound and healthy eyesight is a most precious gift.

The sources of danger and injury in various occupations can be readily summarised. Besides the indirect influence on eyesight of work carried on in hot and dusty rooms, and the strain of fine work done by insufficient illumination, there are a number of direct sources of injury to be considered :—

(1) **Burning of the eyes** by open flames, hot powder, molten and glowing metal, glowing coals and splinters, ashes, scalding liquids and vapour.

(2) **Irritation of the eye** by lime, potash, soda, nitric, sulphuric, carbolic and other acids; aniline dyes, nitronaphthaline, dimethylsulphate, and other organic chemical products.

(3) **Mechanical injury to the eye** through blunt blows, explosions, gunfire, and the impact of foreign bodies of all sorts.

All these occasions of injury can be considerably diminished, if not entirely avoided, by timely precautions in work, protecting appliances, and proper medical treatment.

Therefore, study this advice and read carefully the following suggestions in order to keep yourself free from injury and your industrial efficiency unimpaired.

The following are the chief precautions to be borne in mind :—

(1) Make quite sure, before you decide your vocation, whether your eyes are adapted to it. **There are many trades and industries that require particularly good eyesight.** If there is any doubt consult your doctor; either your family physician, or the school or industrial medical officer.

(2) Be warned by any disturbance of vision or diminution in powers of sight. **Consult an oculist** if your doctor thinks necessary and buy no glasses except under his advice.

(3) **Using the eyes without sufficient light,** i.e., in twilight, or by inadequate artificial illumination, is very detrimental. This applies particularly to fine work, clerical and calculating operations, lithography, type composition, engraving, fine metal work, knitting, &c. In order to avoid your eyes becoming weak or shortsighted keep them at a suitable distance from the work. The distance from the work to the eyes should not be less than 33 centimetres (approx. 1 ft. 1 in.). In the intervals of work **rest your eyes,** take every opportunity of gazing at distant objects; when you have leisure occupy yourself with outdoor games and walks.

(4) **Concentration of blood to the head** may also be productive of injury to eyesight. Therefore wear roomy collars and loose clothes; avoid highly spiced dishes and strong tea and coffee. Excessive tobacco and snufftaking may affect and even permanently injure the powers of vision. Keep your habits regular and your feet warm.

(5) **Strong radiation of heat,** such as is encountered by workers at open fires, furnaces, &c., may injure the eyes. Suitable heat-screens, protecting glass goggles, &c., should be used to ward off these rays.

(6) **Excessive light falling on the eyes** from the direct rays of the sun or brilliant daylight may be very dangerous. At close quarters powerful artificial light, such as that from the unscreened electric arc light, must be guarded against; similarly masses of glowing material, such as occur in auto-welding operations, brilliantly illuminated white surfaces (snow, paper, linen, &c.), cause glare, pains in the head and eyes, and in certain cases may even cause permanent injury or complete blindness. Therefore protect the eyes from such objects by sufficiently large smoked grey protecting glasses or screens. Avoid looking with the unprotected eye at bright light, and do not carry out work in direct sunlight. Similarly, the observation of eclipse phenomena without suitable eye-protection may cause damage to eyesight.

(7) It is well known that many eyes are injured in childhood by "knives, forks, scissors, and light." How much more should grown-up people protect their eyes from injury, for they are engaged in occupations wherein damage to the eye is frequent.

Injuries to the inner eye, eyelids and the tear-sacks should be left to the oculist. For many apparently slight injuries give rise to ultimate trouble when once these parts of the eye are affected.

(8) Among **poisonous materials** from which the eye must be protected may be mentioned various gases and vapours, acids, ammonia chlorine, formaline, &c. Moreover, the eye may be affected by general poisoning of the system, as for example through poisoning by lead, arsenic, sulphuric acid, nitrobenzene, aniline, &c.

Protect yourself from the vapour of such substances by masks and helmets. Absolute cleanliness is very vital. Do not eat inside premises given up to processes of the kind mentioned above, and before every meal wash the hands and cleanse the mouth.

(9) A trifling injury may, if neglected, damage not only one but both eyes. Therefore, if foreign bodies become embedded in the eye, or if it is wounded in any way, seek medical help. Do not try to remove the foreign substance yourself with dirty fingers, handkerchiefs, &c. Leave the injured eye undisturbed until it can receive the attention of the physician. In the case of small injuries no bandage is needed, for the eyelids form a natural screen; for larger injuries a bandage of sterilised lint is desirable.

In the case of irritation caused by soapsuds, acids, lime, plaster, &c., it is a help to allow fresh water to flow between the opened eyelids for some time, the injured person meanwhile being laid on his back. The removal of particles of lime and mortar which irritate the eye cannot be accomplished too soon.

(10) Finally, remember that many so-called internal diseases (anæmia, tuberculosis, &c.), as well as the various skin diseases, may sooner or later affect the eyes. In these cases also prompt medical help is essential.

Not in vain is it written in the Book of Books :—

"**The Eye is the Light of the Body.**"

VAPOUR TUBE LIGHTING OUTSIDE A CINEMATOGRAPH THEATRE.

READERS will recall that about this time last year we gave an account of the lighting of the interior of the West End Cinema (Coventry Street, London), which presented several interesting features.* On that occasion we mentioned our intention of saying something about the outside lighting at a later date, and the illustration on the opposite page, showing the general appearance of the theatre by night, will doubtless interest many of our readers.

During recent years the possibilities of vapour tube lighting for spectacular purposes have received much attention. There are now in existence three distinct forms of tubular lighting, the mercury vapour tube, the Moore light, and the Neon tube, recently invented by M. Claudes in France. The light yielded by the Moore tube, when filled with nitrogen, is a peculiar pink; when carbon dioxide is used the colour is white, and is said to approach very closely to daylight. The neon tubes give a vivid orange-red light, while the colour of the mercury lamps, as is well known, is green. Here we have a great diversity of tint, and the combination of these illuminants seems to offer an interesting field for spectacular and advertisement lighting.

The mercury lamp is of course quite familiar in this country, and the Moore tube has been introduced to some extent. Only a few examples of the neon tube have yet been publicly exhibited, although we were given to understand before the war that it was likely to be more developed shortly. The neon tube, it may be recalled, requires a comparatively high P.D., but apparently not so high as that required for the Moore light, and has the interesting feature that no valve is necessary to keep the gaseous contents of the tube constant.

In the view of the West End theatre both tubes are used. A long length of Moore tube is mounted along the arch, three separate tubes on either side. In additional the words "West End" are traced out in a neon tube over the entrance. The neon tube is said to be very readily shaped in the form of luminous letters.

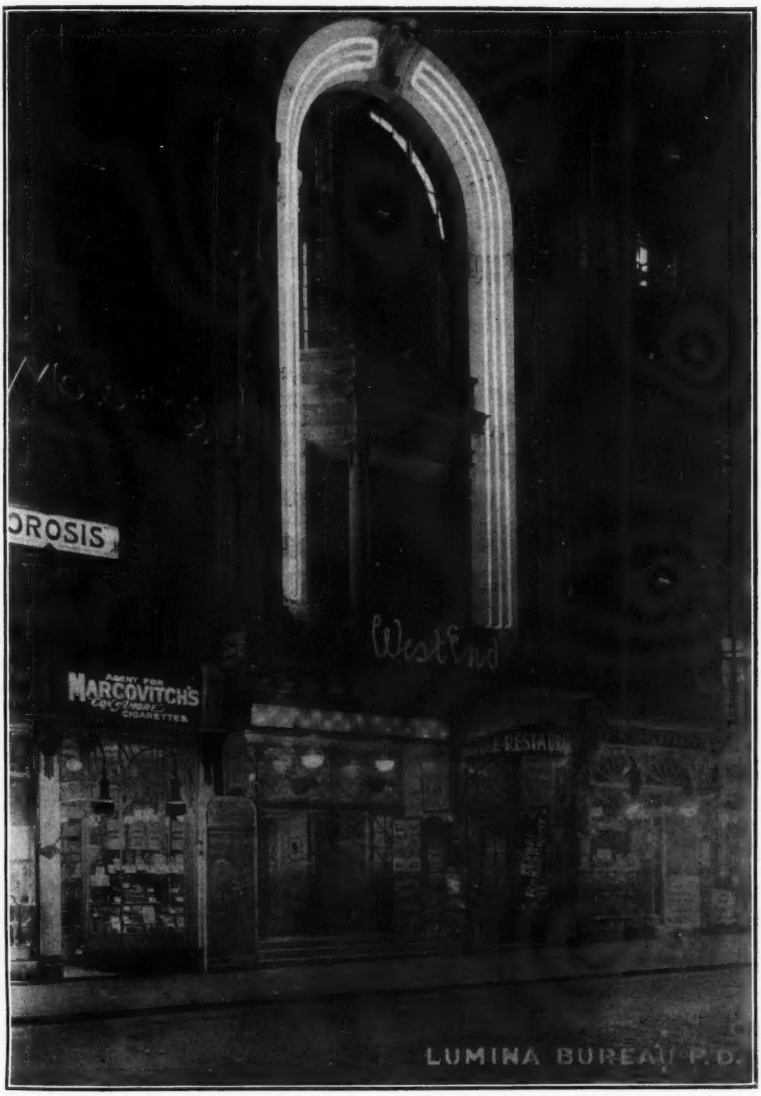
It is interesting to notice that this portion of Coventry Street forms quite an exhibition of lighting appliances. The entrance to the cinema theatre is equipped with half-watt lamps and the shops in the immediate vicinity are lighted with flame arcs and incandescent gas, some of the new high pressure silica lamps being on view.

It is to be feared that the immediate development of the new tube illuminants will be checked by the war, and we have therefore not entered deeply into the technicalities of the neon tube at the moment. But we hope on another occasion to deal more fully with this subject.

* Illum. Eng., Lond., Vol. vi., p. 478.

DEVELOPMENTS IN THE MOORE TUBE.

WE have received from the Luz Moore Artigas C.A. a booklet descriptive of the use of the Moore tube in Spain. Some illustrations are given of the application of the system in the Royal Palace at Madrid, and we hope in a future number to give some further particulars of these installations.



Lumina Bureau Photo.

A view of the outside of the West End Cinema (Coventry Street) lighted in a spectacular manner by the Moore and Neon tubes.

ILLUMINATION IN RELATION TO ACCIDENTS.

AN article in a recent issue of *American Industries** contains some striking facts bearing on the connection between accidents and poor illumination. In a table (reproduced herewith) a comparison of the number of accidents in a large steel works by day and night is given. Clearly there are some occupations where the difference between the figures by day and night is much more marked than others. For example, in yards there are more than *twice* as many accidents at night as they are during the daytime—probably because this is unskilled labour for which very little artificial light is provided. Assuming the work done to be identical the only cause to which the increased number of accidents can reasonably be attributed is the insufficiency of the illumination by night compared with that prevailing in the daytime. In more skilled work good illumination is recognised as necessary from the economical standpoint and the number of accidents is less.

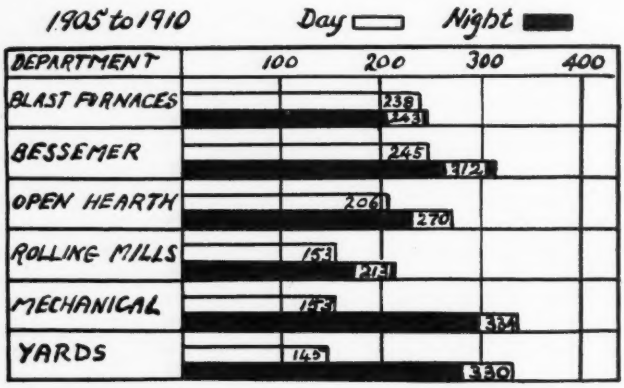


Chart showing number of accidents occurring by day and by night in the various sections of a large steel works in the United States. The figures indicate the number of accidents per 1,000 workers in the course of 300 working days.

The table is reproduced from a Report on the Conditions of Employment in the Iron and Steel Industry in the United States (62nd Congress Senate Document No. 110, 1913; prepared under the direction of C. P. Neill, Commissioner of Labour).

It is estimated that in the United States $250,000,000 is the actual annual cost of injuries to workmen, and that over 50 per cent. of these are preventible. Some experts declare that 25 per cent. of accidents are connected with insufficient light, but sufficiently exhaustive inquiries on this point have not yet been made.

* May, 1914.

SHORT NOTES ON ILLUMINATING ENGINEERING.

HOW BAD LIGHTING CAUSES ACCIDENTS—AN INSTRUCTIVE INCIDENT.

In a paper published in the last number of the Transactions of the Illuminating Engineering Society (U.S.A.), Mr. R. E. Simpson narrates an incident that illustrates vividly how accidents are caused by inadequate lighting.

Two men were at work in a shop lighted by incandescent lamps, equipped with obsolete tin reflectors suspended close to the work. The upper part of the room was in semi-darkness. Some sections of the machinery and floor were brightly lighted, others dim.

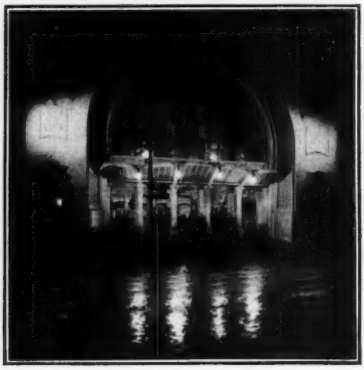
In going from one part of the room to another a workman stumbled over a casting that was lying on the floor. In an effort to save himself he blindly put his hand on the belt-shifting rod which controlled the machine of a worker in the next row. This action threw the belt over and started the machine. By great good fortune this workman was not at his machine at the moment. Had he been adjusting it he would have been totally unprepared for the starting up of the machine, and an accident would almost certainly have occurred.

The two men had a dispute, the first workman blaming the man who left the casting on the floor, while the second accused the first of stupidity. Neither seems to have appreciated the true cause of the mishap. The work on which the first operator had been engaged had a highly polished surface strongly reflecting all the intense light concentrated upon it. When he turned his eyes from this bright material to the rest of the room the comparative darkness of the surroundings made it difficult for him to distinguish the casting. To this his subsequent mistake was due. The incident may seem a trivial one, but the same thing probably occurs in many workshops over the country, and probably it is only an exceptionally well informed inspector who would appreciate the fact that insufficient unsatisfactory lighting conditions was the real cause of the trouble.

SNAP-SHOTS AT THE NATIONAL GAS EXHIBITION.

THESE two photographs are interesting as a reminiscence of the National Gas Exhibition held in October last at Shepherd's Bush.

The first shows the crowd on the steps of the Exhibition, the second people



Lumina Bureau Photo.

examining the cases in the booth containing the collection of ancient lamps.

The fact of its being possible to get these "snap-shots" by artificial light, necessarily taken in a fraction of a second, gives some indication of the

Lumina Bureau Photo.

brightness of the illumination provided by the high pressure lamps shown in the illustrations.

AN ILLUMINATED BARBER'S POST.

THE *Electrical World* describes a novel form of barber's advertisement, erected in Columbus, Ohio, U.S.A. This consists of a square vertical column surmounted by a crossbar bearing two ornamental suspended lamp inclosures. The entire upper part of the post is made up of coloured glass illuminated from within by tungsten lamps. Two lamps are mounted in the body of the post and a single lamp furnishes illumination for each division at the top.

SCIENCE IN GAS LIGHTING.

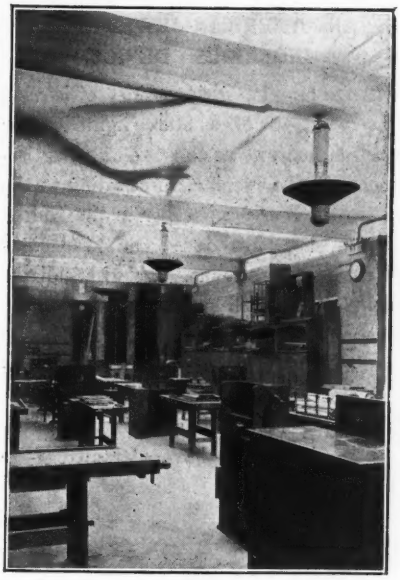
IN addressing the Pennsylvania Gas Association Mr. C. O. Bond recently made the following plea for more scientific methods in illumination :—

"We send experts," he said, "to insure that a gas engine is delivering its rated power, and we send demonstrators to insure that the loaf is baked, or the chicken broiled with a minimum of worry and expense; but do we send a lighting expert in the same way to see that in a room, for instance, with green-hued wall finish, a red or pink globe does not surround the light source, or that children at their nightly study, over an execrable glazed paper, are not supplied with a flickering light or one whose 40 candles per square inch brightness has not been softened to 2 candles per square inch or less, by a diffusing shade or by diffuse reflection, or that sales folk and clerks are not provided with lights and reflectors which illuminate their own faces rather than the material

on which they work? The art of illumination has long existed, but out of its unclassified endeavours the science of illumination is only now arising. The Illuminating Engineering Society sends cordial greetings to the Pennsylvania Gas Association and earnestly invites its members to add to their other methods of efficiency those which our Society promulgates."

INDIRECT ARC LIGHTING IN A WOOD WORKSHOP.

THE illustration on the right shows the wood-working shop at the Arts and Crafts School in Southampton Row. The photograph was taken entirely by the artificial light and gives a good idea of the advantages of this system of lighting, *e.g.*, the penetration of the light into all the corners and recesses. For general work with large materials the method has much to recommend it. On the other hand in fine jewellery work, etc., the general impression seems to be that a powerful well-shaded light close to the work is what is chiefly needed.



Lumina Bureau Photo.

A wood workshop lighted by inverted arcs.

WESTMINSTER SQUARE AT DAWN.

THIS photograph was taken in the early morning, when daylight was just making its appearance, but the artificial lights were still on. It is interesting to recall that the lighting of this square has recently been the subject of much comment. It has been contended that the illumination was not sufficiently bright in comparison with the high-pressure gas in Whitehall, and it has also been suggested that the lanterns should preferably be provided with panes of white glass, so as to appear uniformly bright and show off the metal work to better advantage.

Everyone will agree that this square, one of the most important open spaces in London, should be lighted with special care.

Lumi. a Bureau Photo.

Parliament Square at dawn.

PUSH-BUTTON LIGHTING SCHEME—AN AMERICAN JEWELLER'S INGENIOUS DEVICE.

WE are familiar with the idea of leaving the windows of a store lighted after custom hours so as to serve as advertisements in the evening. According to the *Electrical World* a jeweller in the United States has introduced an ingenious variant of this scheme. He wired all the lights to a push-button switch outside the entrance, over which was fixed a sign reading "You can see our store by pushing this button."

Many people did so. In fact, the scheme is said to have attracted quite a lot of attention.

VOLUNTARY TOWN LIGHTING.

WE note from the *Acetylene Lighting and Welding Journal* that at Whitehead the lighting of the streets by oil lamps was recently carried out solely through voluntary contributions. But Miss Margaret Robinson, President of the Lighting Committee, reported that while some of the ratepayers contributed willingly to the lighting scheme, others did not, and the receipts were insufficient for the carrying out of the work during another year.

It appears that the meeting terminated without any definite arrangements being made for the winter, so that the town was presumably left in darkness, but several of the speakers strongly urged that public lighting should come upon the rates.

This is evidently a case where the enthusiasm of the few did not overcome the inertia of the many. Until people have enjoyed proper illumination, and then have been left actually to do without it, they do not appreciate its value.

LIGHTING A LANDING.

This shows a typical method of lighting small landings. The lamp is covered by a Holophane reflector and over this is placed a Japanese paper shade, the colour of which harmonises with the wall-paper (deep red). Most of the light is directed downwards, but sufficient is transmitted to show off the colours of the shade and beaded fringe.

BLINDED BY MOTOR LIGHTS.

DRIVER OF OMNIBUS FAILS TO SEE MAN IN THE ROADWAY.

THE following note, which appeared in the *Daily Graphic* for Jan. 14th, illustrates the confusing effect of brilliant motor headlights :—

At the inquest at Bedford yesterday on Charles Olroyd, deaf and dumb, who was killed by a motor-omnibus on Saturday night, the driver stated that a brilliantly-lighted motor-car passed him on the road, and he could not see where he was going for some seconds afterwards. He then saw an object lying in the road two feet from the 'bus. One of the wheels passed over it. He stopped and found that it was Olroyd.

The jury returned a verdict of accidental death, and expressed the opinion that these brilliant lights on motor-cars were dangerous.

REVIEW OF THE TECHNICAL PRESS.

IN the *Transactions of the Illuminating Engineering Society* (U.S.A.) there are a number of contributions dealing with **Railway Signalling.** N. BLACK discusses the physiology of the eye in relation thereto, H. P. GAGE describes various forms of glasses, and T. S. STEVENS deals with the matter from the standpoint of methods of illumination. N. Black classifies the various methods of testing colour-blindness in vogue and emphasises the vital importance of eliminating all drivers with defective vision. H. FORD describes the chief forms of **illuminated signs,** including those of the "box" and "combination" types. An interesting curve is given showing the relation between the brightness of letters and the distance at which they are legible.

J. CRAVATH in his paper on "**Brightness**" deals with somewhat similar phenomena. He gives a complete table of intrinsic brilliancy, and illustrates, by a number of examples, the range of brightness that is likely to be met with in an ordinary lighting installation.

Among articles on photometry we may note a short contribution by A. R. MYHILL (*J.G.L.*, July 18th) on the **Pentane Lamp.** He points out the nature of the errors likely to be introduced by small differences in the adjustment of the screen.

Turning to **Electric Lighting** we may note an article by **Eydam** (*L.u.L.*, July 16th), in which there is an exceptionally full account of the various defects leading to failures in electric lamps. He discusses the effect of switching on and off and vibration in revealing potential weaknesses in filament, and there are also many points to be considered in connection with the attachment of filament to electrodes, nature of vacuum, and leakage effects due to gradual after-effects of strain in glass. The author refers to numerous patents on the subject.

M. LUCKIESH deals with the **Half-Watt Lamp in Photography** (*Elec. World*, July 18th). He gives a curve showing that the spectrum composition of its light approaches considerably nearer to daylight than that of the ordinary tungsten lamp; in fact he regards it as similar to the light from the open arc. With a suitable filter the lamp should be useful for orthochromatic photographic work. Its steadiness is also an advantage. It may prove useful for making prints but the speed with plates is said to be only a third to a half of that of the mercury lamp.

In *Science et Art de l'Eclairage* there is an article on the **Moore Light**, and a writer in *Licht und Lampe* deals with some novel developments in the **neon tube.** It is stated that by using subsidiary electrodes of the alkali metals gaseous impurities can be readily absorbed and the life prolonged. The specific consumption is given as $\frac{1}{4}$ watt per H.K. Increased density of discharge does not favourably affect the efficiency but it may improve the colour of the light to some extent.

In the gaslighting journals one of the most interesting contributions is that of LITTLEJOHN (*J.G.L.*, August 25th) on **Street-lighting.** Some curves are given connecting the candle-power of lamps with the desirable height of suspension, and the author also tabulates costs of street-lighting with various numbers of lamps 20 feet high.

AHRENS (*Z.f.B.*, July 10th) describes the principle of the **Keith Silica Lamp,** and there are also contributions dealing with recent exhibitions at Munich and Edinburgh.

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Ahrens, F. Neuere Pressgaslampen (*Z.f.B.*, July 10th).
Editorial. British Gas Appliances at Home and Abroad. (*J.G.L.*, Aug. 25th).
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Littlejohn, M. Economical Streetlighting (*J.G.L.*, Aug. 25th).
New Office Building of the Portland Gas Co. (*Am. Gaslight Jour.*, July 20th).
Opening of Model Rooms at Edinburgh (*J.G.L.*).
More thoughts from Munich (*J.G.L.*, Aug. 4th).

CONTRACTIONS USED.

E.T.Z.—*Elektrotechnische Zeitschrift.*
G.W.—*Gas World.*
J.f.G.—*Journal für Gasbeleuchtung.*
J.G.L.—*Journal of Gaslighting.*
T.I.E.S.—*Transactions of the Illuminating Engineering Society (U.S.A.).*
Z.f.B.—*Zeitschrift für Beleuchtungswesen.*
L.u.L.—*Licht und Lampe.*

ERRATA.

August Issue, Vol. VII., No. 8.

Page 406, in the List of Members of the Illuminating Engineering Society, for "G. Heilig, Officer in Charge of the Birmingham Gas Dept.," *read* "G. Heilig, Officer in Charge of the Mantle Maintenance Dept.," &c.

Page 416, in List of Members of the Illuminating Engineering Society, for "Weiss, A., Electrical Engineer General Electrical Co.," *read* "Weiss, A., Electrical Engineer, General Electric Co., Ltd.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

MAZDA "HALF-WATT" LAMPS IN LEEDS CITY SQUARE.

We have more than once referred to the need for original design in connection with public lighting and instanced the arrangements on one of the Continental bridges where the illuminants on the parapets are carried by statues.

Another example is supplied by the statue in Leeds City Square, shown in the illustration. This was described in a recent number of the *Mazda House News*. The lamp here is stated to serve a double purpose, showing up the statue and illuminating the roadway. It is a fact that most public statues are condemned to invisibility by night and it is only rarely that any systematic attempt to illuminate them has been made. The effect in this case is said to have been much appreciated in Leeds. Curiously enough the use of half-watt lamps for public lighting seems to have made greater strides in the provinces than it has yet done in London. No doubt this is only a passing phase and we shall see many more examples in London before long.

The Lady with the Lamp.

One of the statues in Leeds City Square, carrying a half-watt lamp.

THE LAMP SITUATION.

Readers will recall that in August, 1911 (three years ago) a visit of the technical press to the British Thomson Houston Lamp Works at Rugby took place, and Mazda drawn wire process was first described. In addition to lamps of the ordinary kind the British Thomson Houston Co. inform us that during the last year they have been busily engaged in the manufacture of half-watt lamps, and that these lamps are now being produced in commercial quantities at Rugby.

At the present moment this information is of considerable interest. It is stated that "The British Thomson Houston Co. is in the fortunate position of being able to guarantee that all its lamps, Mazda and Carbon, of every type and size are made in Great Britain by British workpeople."

HALF-WATT LAMPS AT LIVERPOOL STREET STATION.

The accompanying two photographs illustrate the use of Wotan half-watt lamps at Liverpool Street Station. Fig. 1 shows a view of the main gateway, taken from inside. The lanterns contain 500 watt lamps and the photograph gives an excellent impression of the brightly illuminated notices on the gates.

Lumina Bureau Photo.

Platform at Liverpool Street Station illuminated by Wotan half-watt lamps.

Half-watt lamps have also been very extensively installed within the station, but, being mounted in the globes formerly used for the arc lamps it is possible that the change has not been observed by the general public. Fig. 2 is a view of the platform so lighted. Down the length of this platform there are five lamps in all at a height of about 30 feet above the ground, which are stated to give about 1000 candles each. Owing to the diffusing effect of the glass the light is not glaring and the platform certainly gives the impression of being unusually brightly illuminated. A recent test showed that along the edge of the platform illumination values varying from 0·4—1 foot-candle were recorded. It was recently suggested at a meeting of the Illuminating Engineering Society that a minimum of 0·25 foot-candles would be considered good practice for main station platforms. In this case the prescribed value appears to be exceeded, and there is little doubt that half-watt lamps will be very widely used for railway station lighting. For some of the information utilised in this article we are indebted to the courtesy of **Messrs. Siemens Bros. Dynamo Works Ltd.** The photographs shown were taken entirely by the artificial light of the lamps shown.

THE SUPPLY OF CARBONS IN WAR TIME.

A crisis such as that provoked by the present European War must open the eyes of the lighting industry to many facts which it did not before appreciate at their proper value. People are only now beginning to realise that there are many things—not luxuries, but actual necessities—for which we are almost entirely dependent on foreign manufacture. Now the connection with the Continent is abruptly broken and we are waking up to the need for a home source of supply.

A case in point is the manufacture of carbons. As is well known, many of these come from the Continent, and the shortage caused by the war may mean considerable inconvenience in the lighting industry. But the supply of carbons for searchlights is at the present moment an even more vital matter. When our safety is dependent on the efficiency of our fleet a shortage here would be highly inconvenient, and the existence of a factory and raw material in this country has doubtless been helpful in enabling the Admiralty to make full provision in this respect.

It is therefore only just to recognise the enterprise and foresight of the management of the General Electric Company in establishing, despite considerable initial difficulties, the carbon works at Witton. The existence of this home source of supply is of incalculable importance at the present moment, and fully justifies the efforts of those responsible for its inception.

Lumina Bureau Photo.

The Gateway at Liverpool Street Station. 500-watt "half-watt" lamps are used in the lanterns.

EMERGENCY LIGHTING IN WAR.

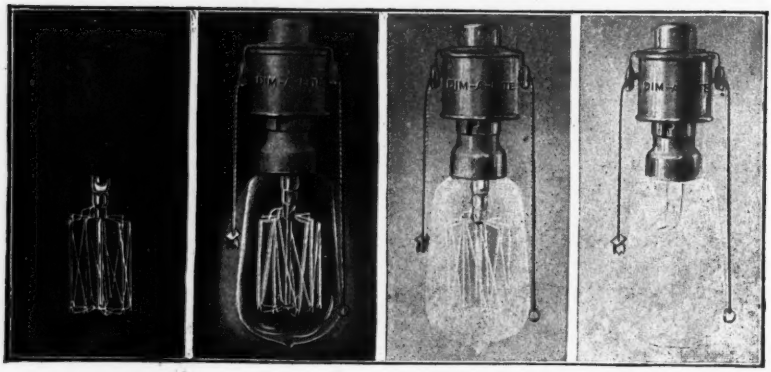
The events of the past month must have brought home to many the important part played by lighting in war. Searchlights have a great influence in military operations on land, sea and even in the air. Portable illuminants have a special value in the field—for Red Cross work especially, where powerful self-contained illuminants capable of giving a strong illumination but readily movable from place to place are required.

We understand that several of the prominent acetylene firms have been supplying flare lights and other appliances for use on land and on board ship and quite a number of the portable tent-lighting outfits of the type made by the Thorn and Hoddle Acetylene Co. have been taken by officers to the front.

For field hospital lighting apparatus of this kind should be most useful. Another form of illuminant which deserves to be even more widely known in this connection is the Blanchard incandescent oil system. These lamps have been much used of recent years in connection with fêtes, country meetings, territorial camps, &c., and for emergency work in camp hospitals they would seem to have a special applicability.

Emergency lighting has, in fact, a field of its own in times of war. We notice that in the recent naval action off Heligoland one of the British vessels was reported to have been put out of action quite early in the engagement (although sound in other respects) owing to a shot being planted in the midst of the electric lighting set. This, too, seems to suggest an opportunity for a spare system of "self-contained" illumination.

BENJAMIN-WIRT DIM-A-LITE.



NIGHT LIGHT. DIM. HALF. FULL.

The "Dim-a-Lite" is a "turn-down" attachment for electric lampholders. It is a compact rheostat, fireproof and unbreakable. The operation is most simple, as you simply pull a cord for the different changes of light: "full," "dim," "low," "night-light" and "out."

At the present moment when most people (even if patriotically determined to keep to the motto "business as usual") are alive to the necessity for judicious economies, this little device supplied by **Benjamin Electric Ltd.,** 1A, Rosebery Avenue, London, E.C., should be interesting to many of our readers.

The picture is really self-explanatory. The "Dim-a-Lite" consists of a compact fire-proof rheostat built into the lamp holder, which enables the light to be cut down first to half, and then by stages to the "night-light" condition. For sick rooms this device would seem to have a field of its own and one would also suppose that it would be useful in railway carriages where most passengers are conscious of the need for a moderation of the normal illumination during a night journey.

As regards their reflectors and other lines of fittings we are given to understand that the Benjamin Electric are not affected by the present situation to any great extent.

The company has ample stocks in hand and is in a position to manufacture all their most important units in this country.

NATIONAL SERVICE FOR ELECTRICAL ENGINEERS.

At the present moment there is a need for men with special electrical knowledge and the Institution of Electrical Engineers is enrolling those who are in a position to help.

The two chief opportunities for service for electrical engineers are :—

(1) To place their services as Electrical Engineers at the disposal of the War Office and Admiralty.

(2) To be in readiness to fill vacancies in public services, electric power stations, tramways, railways, &c., caused by the calling up of reserves and territorial forces.

All those who are able to assist in these respects are asked to send their names in to the Secretary of the Institution (Victoria Embankment, London, S.W.) without delay.

THE LIGHTING OF A MINIATURE RIFLE RANGE BY GAS.

THE accompanying illustration is reproduced from a photograph kindly put at our disposal by the **Gas Light & Coke Co.**, and is of special interest at the present moment. It shows the gas lighting in the miniature range of the Marylebone Rifle Club, where there are two rows of targets lighted by screened gas lamps. The intention in this case is to produce a powerful but even illumination all over the targets, each one receiving the same amount of light. The targets should naturally be more brightly lighted than their surroundings. It is a well-known principle that the eye is most readily concentrated on the brightest object in the field of view, and it is equally important that the eye should not be fatigued or dazzled by any exposed lights. The metal shields—of which one has been removed temporarily in order to show the arrangement of the lights—screen the direct source of light entirely from the eyes of those firing. The targets thus "stand out" brightly illuminated amidst black surroundings.

Another feature of interest is that the lamps are controlled from the end of the room where firing takes place. As a measure of safety this is very desirable, since it removes any likelihood of a person being at the target end in order to turn up the lights while firing is on. It also enables the Range Master to turn off the lights immediately each detail has fired and to turn them up again when practice recommences—which of course makes for economy.

HOLOPHANE GLASSWARE IN THE EAST.

We notice, in a recent issue of *Holophane Illumination*, some account of the development of illuminating engineering in the Far East. In the Treaty Ports of China, for example, more up-to-date forms of illumination are replacing the primitive illumination by a wick used in vegetable oil, which still prevails in the interior.

It appears that this is an excellent outlet for Holophane Glassware. The familiar cabinet, containing a bare lamp on one side and a similar lamp in a Holophane reflector on the other, should readily demonstrate to the merchants in Hong Kong and Shanghai the advantages of proper shading appliances.

At the present moment, when everyone is talking of the extension in overseas trade that is likely to follow the paralysis of Continental industries owing to the war, this development in China is not without significance.

THE NEW WOTAN HELICAL TRACTION LAMP.

A recent development in tramcar lighting is the new Wotan Helical Traction Lamp introduced by Messrs. Siemens Bros. Dynamo Works, Ltd. This utilises a spiralised tungsten filament carried on a spider in the usual Siemens manner, but instead of the filament being wound up and down there are equal vertical and horizontal lengths. Besides having exceptional mechanical advantages this gives rise to a considerably increased spherical candlepower as compared with the ordinary arrangement.

Messrs. Siemens Bros. Dynamo Works, Ltd., also inform us that they have received a contract for 12 months' supply of Wotan drawn wire tungsten lamps to the H.M. Office of Works, and like also an order for the supply of 125,000 Tantalum Traction Lamps for the London County Council.

It is stated that practically all the lamps used on the L.C.C. trams during the past two years were of the "Tantalum" type.

EDISWAN BUSINESS AS USUAL.

The Ediswan Company inform us that if they could coin a phrase out of the mottoes they have recently seen it would be "Don't Worry—Work and keep on at it during the alterations to the map of Europe."

The staff of employees in the Royal Ediswan Lamp Manufacturing Section is being added to daily and full time worked; this is owing to increased orders for all makes of Royal Ediswan Lamps.

The effect of advertising to the trade through the trade papers, the fact that Royal Ediswan Drawn Wire and Carbon Lamps are made in Great Britain by British labour with British capital has had a very successful and patriotic effect.

It is as yet a case of "counting chickens before they are hatched" or, in other words, "lamps before they are made," but the *All*-British effect, including British capital, is likely to tell with the Ediswan Company in the near future in a very marked degree. We shall find that the public will be, and in fact have to be, far more patriotic in their buying and we think that English-made and English-backed goods will govern the market. The Company have every confidence in the present general situation and in their ability to meet all demands now and in the future, and no effort will be spared to maintain their usual service to the trade.

The Ediswan Engineering Section is able to speak with equal confidence, not only because of the increased activity caused by Admiralty work, but also by the continuation so far of everyday orders, and in fact increased orders for many special lines.

It is worthy to note that the firm are paying the wives of the married men serving in the Army half pay, and will allow them to take over their old positions upon return.

According to a circular subsequently issued by the company on August 24th we note that large stocks of finished lamps as well as raw materials are available and this will enable the company to cope with the exceptional demand for Royal Ediswan lamps. It is stated that the company is not dependent on Continental supplies of lamp bulbs, &c., and that there are ample facilities for making these in the glasshouses at the Ediswan works.

CORRESPONDENCE.

THE LIGHTING INDUSTRY AND THE WAR.

DURING the past month there have been many rumours as to the injurious effect of the war on the lighting industry.

In particular, fears have been expressed that the supply of lamps and mantles would not be sufficient to meet immediate requirements. In order to ascertain how the chief difficulties at the present moment can best be met, we have addressed a letter to some of the leading manufacturers of lamps and lighting appliances, asking them to state their views on the situation.

In order to survey the situation completely, an exhaustive official inquiry would naturally be needed. But, according to the letters so far received, it would appear that the general impression is reassuring. Everyone is taking as his motto "business as usual," and the leading firms are already actively at work to make good as far as possible the deficiencies caused by the severance of contact with the Continent.

ELECTRIC LAMPS.

August 28th.

DEAR SIR,

In reply to your favour, I wish to assure you that we do not anticipate a stoppage of the supply of Osram or Robertson Lamps during the war whatever may be its duration.

Both in the Osram and Robertson factories we manufacture lamps and all the component parts required in the lamp industry, starting from the raw material, more particularly, the filaments and bulbs.

It is not likely that a dearth of the raw materials which we require will occur. In any case, we have already sufficient stocks to last us at least twelve months, assuming the business to remain of the same dimensions as last year.

Owing to the encouragement which we have given our Staff and Workpeople to enlist, we are at the present moment somewhat short-handed, and this no doubt will cause a temporary reduction in our output, but the ample stocks of finished goods that we have prepared for the coming season will enable us to overcome this difficulty without any inconvenience to the trade or the public.

Yours faithfully,

H. HIRST,

(Chairman of the General Electric Co., Ltd.).

August 18th.

DEAR SIR,

Replying to your enquiry in your letter of the 18th inst. as to the effect of the war on the lighting industry and the supply of lamps, we would advise as follows :—

Mazda Lamps and Carbon Lamps supplied by the British Thomson-Houston Company are manufactured at Rugby. The Mazda Lamp Factory is completely equipped, and is now producing and supplying all sizes and types —from the Battery and Automobile lamps up to and including the latest types and sizes of half-watt lamps.

All the Tungsten Wire required for the Drawn Wire filaments of Mazda Lamps is, and has been, produced at Rugby. The Company has ample supplies of the regular types of Mazda Lamps, and a materially augmented productive capacity, so that they expect to be able to supply all reasonable demands for lamps of the standard sizes and types during the coming season.

In particular regard to the Mazda Half-watt Lamps, the Company has been manufacturing these lamps for some

months at Rugby, and have been steadily increasing their facilities, so that they are to-day turning out these lamps in large commercial quantities. Orders for these lamps will be filled in strict order of rotation, and customers will greatly assist to ensure the supply of what is required by placing advance orders for these half-watt lamps to cover their needs.

Yours very truly,
F. W. WILLCOX
(General Manager, Lamp and Wiring Supplies Dept., British Thomson-Houston Co., Ltd.).

August 21st.

DEAR SIR,

In reply to your favour of the 18th inst., it is, as yet, too early to make any definite reply to the various questions you put before us.

At the present moment we have very sufficient Stocks, not only of the ordinary Lamps used for Domestic Lighting, but also of the High Candle Power Sizes, including Half Watt Lamps.

We certainly do not yet anticipate being in any difficulties over the Supply of Raw Material, &c., although the Demand for our Lamps at the present time is phenomenally high.

As you are doubtless aware, for a very long time past, we have been making the best part of our total Lamp Supplies in these Works.

Yours faithfully,
E. C. LAUGHTON
(Siemens Bros. Dynamo Works, Ltd.).

August 19th.

DEAR SIR,

I am obliged to you for your letter of yesterday's date, and I need not assure you that I would only be too glad to supply you with the information you require if I were in the fortunate position to survey the present condition of affairs so clearly as to enable me to give a reliable opinion.

No doubt you are aware that the present crisis has largely interfered with commerce and industry and it will require some time before all those engaged in responsible work will be able to decide upon a course which will be most conducive to their relative businesses.

My firm is busily engaged in making every possible effort for the purpose of keeping our works as fully employed as possible, and all that is in our own power for this purpose will and must be done. The question of foreign supplies for British industries is one that seriously hampers the smooth working of the industrial enterprises, but I have no doubt that the ingenuity and commercial talents of British industries will speedily find a way to overcome the existing difficulties.

I fully agree with the view that it would be most desirable to arrange matters in the future in such a way that the manufacturers in this country should never be entirely or partially dependent on foreign countries for supplies, and I think that the present conditions will be the means of making everybody take steps that in future dislocation of business on account of shortage of foreign supplies will be obviated.

In conclusion, let me once more express my regrets that my report to you does not contain any definite suggestions, but you will easily understand that after the sudden appearance of such a calamity one has hardly had sufficient time to go into matters as seriously and thoroughly as to form a decided opinion as to what to do for the best in the future.

I am,
Yours, &c.,
C. REISS
(Brimsdown Lamp Works, Ltd.).

August 24th, 1914.

DEAR SIR,

The public I think may be reassured on the question of supplies of incandescent electric lamps during the continuance of the War.

Manufacturers in this country I believe hold very large stocks of lamps, and the producing facilities are such as to enable them not only to supply the general public, but to execute large emergency orders for the Government, and in addition to offer considerable quantities of lamps for export.

The half-watt type of lamp may be in a different position, as the larger plants for production of this kind of lamp were in operation in Germany in advance of this country, and it is possible that a temporary shortage may occur, but it is difficult to see that any serious inconvenience will be caused in this direction as there are large supplies of high candle-power tungsten lamps of ordinary variety available.

Naturally, the manufacturing facilities in this country depend upon the continued and adequate supplies of raw materials. In this matter you will probably find that manufacturers are in a good position, and it is certainly the case that the oldest incandescent lamp manufacturing concern in this country (the

Edison & Swan Company) have always been in the position of being able to manufacture everything in connection with incandescent electric lamps entirely from the raw materials in one self-contained factory.

All the raw materials necessary for the manufacture of incandescent lamps are obtainable within the Empire.

Yours faithfully,

E. GIMINGHAM.

(Director of The Edison & Swan United Electric Light Company Limited.)

GAS LAMPS AND MANTLES.

August 21st.

DEAR SIR,

With reference to your inquiry regarding the effect of the present war, I may say that I have received and filled up a form from the Board of Trade bearing on this point, and I pointed out then the difficulty of saying anything very definite as yet. No one can foresee what the conditions in a few months time may be, although most of us believe that eventually British industries will resume their normal course and even be more prosperous than before the war.

Meantime we are faced by a shortage of many materials. The probability of a shortage in mantles has received much comment. It may interest your readers to know that during the last week we have received large consignments of mantles from our works in Belgium, actually at work less than 50 miles from the seat of war. There is also the difficulty of getting glass and porcelain, and many other things hitherto supplied by Germany. We have already given orders for thousands of china parts for burners to be made in this country. They will cost more than the corresponding German or Austrian goods, but they can be made in this country and will enable us to carry on.

There are of course countless other sources of dislocation, for example, the fact of the Government taking control of the supply of spelter and lead. But before long additional supplies should be available and the price of metals should return to a more normal figure, and the Government can help by securing continuity of supply.

To put the matter shortly, I believe that although the experience of the next few months will doubtless be trying the ultimate results will be good. The present is a time of activity and adaptation to the new conditions, not of stagnation. The immediate effect will be that many things previously made in Germany will now be manufactured in this country, and in time to come we should be in a position to supply many necessities for which we are at present dependent on foreign countries.

Believe me,

Yours, &c.,

J. BRIDGER,

Managing Director, the New Inverted Incandescent Gas Lamp Co., Ltd.

August 30th, 1914.

DEAR SIR,

In answer to your letter I may say that the present situation is naturally causing inconvenience to us, as to all firms in the lighting industry, but that we have every intention of carrying on business as usual and have ample stocks of most materials for some time to come. For example, we hold stocks of mantles that should suffice to meet our normal demand for six months, and although high pressure mantles require more thoria than those intended for use with low pressure we do not anticipate any serious difficulty in providing what may be required.

We are also proceeding with the manufacture of our lamps as usual, and as these lamps are now being made entirely in this country there is no reason to fear interruption of the supply.

As regards glassware, we are prepared to supply all required for high pressure lamps, and, as is well known, the cups used on our silica lamps are of British manufacture.

We quite agree as to the desirability of arranging matters so that this country should never be entirely dependent on abroad for supplies, and for some time we have been aiming at putting our business on such a footing. The present opportunity should be taken advantage of to foster this tendency, and we have little doubt that in the future the effects of the present situation will not only cease to be injurious but will even be beneficial in enabling us to do business on a bigger scale than before.

I am, Yours, &c.,

G. KEITH.

(Messrs. Jas. Keith & Blackman & Co., Ltd.)

In connection with Mr. Bridger's letter the following summary of the situation, as outlined in the gas journals, may be of interest :—

THE SUPPLY OF MANTLES IN GREAT BRITAIN.

During the last month the question of the supply of mantles has given natural concern to the gas industry. It was only after war broke out, and contact with the Continent was abruptly severed, that the position was realised. The facts were summarised by Dr. Carpenter in his address at the annual meeting of the South Metropolitan Gas Company on August 12th. He pointed out that 75 per cent. of the mantles used in this country had been coming from Germany. When one considers that of the remaining 25 per cent. of mantles a considerable proportion probably comes from other Continental countries (even during the last month supplies have been received from Belgium), and when one considers further that even the few companies in this country that make mantles derive their chemical materials mainly from abroad, one can appreciate the seriousness of the situation.

Fortunately Dr. Carpenter, besides emphasising the seriousness of the position, was able to make the interesting announcement that the South Metropolitan Gas Company has available a considerable store of thorium nitrate, the chief ingredient in modern mantles. At a time when, it is known, the stocks of makers in this country are of necessity low, this reassuring announcement has been widely quoted.

The *Journal of Gaslighting* recalls the action of Sir George Livesey, who in August, 1905, referred to the purchase by the company of a monazite deposit in North Carolina. At the time the importance of the step was hardly sufficiently understood. Now all can appreciate the foresight of Sir George and the South Metropolitan Gas Company, who ten years ago saw the weakness of relying on supplies of thorium nitrate drawn entirely from abroad.

Summarising the position the *Journal of Gaslighting* remarks : "The British Gas Industry must not be caught napping again ; nor must it allow itself to help to perpetuate the old charge of lack of enterprise and encouragement in support of British manufactures. On this occasion it is protected from danger. By whom and by what ? The South Metropolitan Gas Company and their enterprise a decade ago."

We have recently had the opportunity of ascertaining the views on the situation of a firm closely associated with the mantle industry. It was pointed out that although the supply would probably last for some months, and there was no immediate cause for anxiety on the part of the public, yet the permanent manufacture of mantles in any quantities in England presented considerable difficulties. Thorium nitrate is one of the chief materials required, and it is something to the good that we have at present a fair store available. Nevertheless there are very few people in England who can apply this product to the manufacture of mantles on a large scale. It has been suggested that the Government might secure a supply of monazite sand from Travancore, but the question is raised whether chemical works in this country have at present the facilities for extracting thoria in bulk from this material. Nor should it be overlooked that there are other chemicals required for mantle manufacture besides thorium nitrate, and that there are other sections of the mantle industry, the preparation of Ramie for example, which are almost entirely in foreign hands. Evidently besides the difficulty of obtaining materials we have still to grapple with the problems involved in their successful utilisation.

THE ACETYLENE INDUSTRY.

August 21st.

DEAR SIR,

In reply to your inquiry as to how the war is affecting the acetylene industry, I should like to say that on the whole business is not so much affected as might be expected. There seems less likelihood of serious dislocation than what I understand is likely to occur in the gas and electrical trades, chiefly because we are not so dependent on supplies from the Continent. A small quantity of carbide is manufactured in England. This of course is not sufficient to supply the demand, but it should at least be of assistance and would be capable of extension in times of severe need. Cargoes have recently been received from Norway and Sweden which are sufficient to meet present needs, and doubtless this source of supply will be kept open. The first consequence of the war was a tendency to "hoard" carbide, and the price rose temporarily to £1 a cwt. This had the effect of checking the hoarding, and the present price is about 15s. per cwt., which is only slightly above the ordinary figure.

(*Continued on page 466.*)

EXTRA ITEMS.

WANTED, a man with technical knowledge of enamelling processes and manufacture of enamelled iron reflectors, &c. Apply, giving particulars of experience, c/o "The Illuminating Engineer," 32, Victoria Street, London, S.W.

—o—

University-trained Engineer, A.C.G.I., B.Sc. (Eng.), D.I.C., with knowledge of French, German, and Roumanian, seeks employment. Would be satisfied with small initial salary in position offering good prospects of advancement. Apply "Engineer," c/o "The Illuminating Engineer," 32, Victoria Street, London, S.W.

NATIONAL RELIEF FUND.

[At the present time many readers of "The Illuminating Engineer" are doubtless experiencing the dislocation of trade caused by the war and appreciate only too well the distress that may result. We all hope and believe that the trouble is only temporary and that eventually our industries will be more prosperous than ever. Meantime it is our duty to "hope for the best but prepare for the worst," and especially to see that the relatives of those who have gone to the front do not suffer.

Everyone can help a little and the readiest way of doing so is to subscribe to the National Relief Fund, making use of the coupon reproduced below.—Ed.]

I enclose £ s. d. toward the Prince of Wales'

NATIONAL RELIEF FUND.

Name .....

Address .....

.....

This coupon should be filled in, and the envelope, which need not be stamped, addressed to H.R.H. The Prince of Wales, Buckingham Palace, London.

National Relief Fund.

Treasurer: H.R.H. THE PRINCE OF WALES.

Joint Secretaries { C. ARTHUR PEARSON. / HEDLEY F. LE BAS. / SIR FREDERICK PONSONBY, K.C.V.O., C.B.

YORK HOUSE, ST. JAMES'S PALACE, S.W.

To The Editor,

Dear Sir,—We regret to say that the Subscription Sub-Committee of the National Relief Fund has heard of a good many cases in which use has been made of its name, or of the names of those connected with it, with the object of securing support for appeals which are quite unauthorised.

We hope you will be so good as to permit the appearance of this letter, the object of which is to inform your readers that they may be assured that any extravagant or grotesque appeals emanate from persons who have neither the authorisation nor the support of this Committee.

Yours faithfully,

C. ARTHUR PEARSON.
HEDLEY F. LE BAS.
FREDERICK PONSONBY.

Joint Secretaries,
Subscription Sub-Committee,
National Relief Fund.

August 24th, 1914.

On the other hand, we should be prepared for a temporary increase in the amount of carbide used. The Admiralty for example are at present demanding exceptional supplies for oxyacetylene welding and cutting work, and no doubt flare lights and search lights will be also required in unusual quantities for military purposes. Moreover, it is possible, in the event of the supply of mantles falling short, that there will be a call for emergency lighting by acetylene. Fortunately, while it is true that much foreign-made apparatus is sold in this country, there are in existence many firms who make their own generators, lamps, oxyacetylene welding outfits, &c.; in view of the obvious industrial value of such processes as acetylene welding this is an important point, and it would also seem desirable to ensure that supplies of oxygen and carbide would always be forthcoming, whatever the complications abroad.

As regards other branches of the acetylene industry, for example, country house lighting, there is naturally some falling-off in business at the present moment; but fortunately this is neutralised to some extent by the exceptional demand in other directions. Naturally, our company is making provision for those who have gone to the front; besides those who have been called to the army there are some who have been requisitioned as welding operators, so that the acetylene industry may claim to be playing a not inconsiderable part in this war.

Believe me,
Yours, &c.,
C. HODDLE,
Managing Director.
(Thorn and Hoddle Acetylene Co., Ltd.)

DEAR SIR, Aug. 24th, 1914.

In reply to your letter *re* carbide, the greater part of the carbide used in this country comes from Norway and Italy, and a part comes from the British Factory at Thornhill. At the time war was declared there was a normal amount of carbide in this country, but because of the fear that ships would not be able to get through from the Continent, merchants limited supplies to the Government contracts and urgent orders.

Within the last few days cargoes have arrived, and there is every reason to believe that there will be plenty of carbide, but the price will be higher owing to the rise in freights and the very heavy insurance.

I am,
Yours faithfully,
IMPERIAL LIGHT, LTD.

(We have made inquiries of several others associated with the acetylene industry and the general impression seems to bear out the views expressed in the letters given above.

It is possible, however, that some of the specialities, such as the incandescent projection lamps using small discs of ceria, may be affected to some extent.

We may add that we have since received a letter from Mr. T. E. Allen (President of the Acetylene Association), who states that he has been assured that, at the present moment at any rate, there is no anxiety as to failure of supply of carbide.—ED.)

PETROL-AIR GAS LIGHTING.

The Secretary,
The Illuminating Engineering Soc.
28th Aug., 1914.

DEAR SIR,

In reply to your inquiry regarding the effect of the War on Petrol-Air Gas lighting, we are, so far, hopeful that the Industry will be able to maintain its position. The maintenance of the mantle supply is of course essential to us in common with the rest of the Gas Industry. We suggest that in this respect the Board of Trade might be able to assist not only in securing supplies of the Thorium and other natural products necessary to the manufacture of mantles, but also in making it impossible for any attempt at *cornering* these products to fail.

So far as the supply of the petrol we use is concerned we have had no difficulty and there has been no increase in price.

We hope that private as well as public schemes for building, etc. which were projected for the autumn will be carried through as far as circumstances permit as this will do untold good in steadying those numerous forms of industry—such as lighting, hot water, and similar work—which depend on such schemes.

We are glad to state that so far we have not had a single contract cancelled.

We remain, Sir,
Yours faithfully,
THE COUNTY LIGHT, LTD.,
C. P. BLATCHLEY
(Managing Director).

INDEX, September, 1914.

	PAGE
Brightness, Measurement of	437
Correspondence, "The Lighting Industry and the War"—H. Hirst—F. W. Willcox—E. C. Laughton—C. Reiss—E. Gimingham—G. Keith—J. Bridger—C. Hoddle—C. P. Blatchley—H. H. Thompson—J. Eck ..	461
Editorial .. .. L. GASTER ..	433
Eyesight, Protection of	443
Factories, The Lighting of	441
Illumination in relation to Accidents	448
Illuminating Engineering, Short Notes on	449
Review of the Technical Press	453
Topical and Industrial Section	455
Vapour Tube Lighting outside a Cinematograph Theatre	445

ILLUMINATING GLASSWARE.

Aug. 29th.

DEAR SIR,

You ask in your letter of the 28th whether the War will have any effect upon the manufacture of Holophane Glassware and in answer we would say that fortunately it has been the policy of this Company to have its products manufactured in this country and with this in view a very considerable amount of money has this year been spent in the production of the necessary moulds. In addition we carry large stocks both at our stores and at our works so that we can hardly conceive that circumstances will arise of such a nature as to prevent us dealing with our orders as promptly as usual. In saying this, it should, of course, be remembered that the best glass depends very materially upon its supplies of sand (and oil) which may be curtailed and there is just the possibility of difficulties in both these directions.

We feel some little satisfaction that even in a small portion of the lighting business such as ours is, that we shall be able to meet the demands of those of our customers who have appreciated the pioneer work done by us in connection with scientific illumination generally.

We certainly agree that it is desirable to manufacture as much as possible, independently of foreign sources; but how far this is possible, bearing in mind the amount of raw, and partly manufactured material which comes from other countries, is somewhat difficult to estimate. Experience would tend to show that in a country situated as ours is, it is difficult, if not impossible, to be independent of the supplies from others and this is likely to be illustrated in the electrical industry within the next few months.

It is desirable to the highest degree that earnest efforts should be made to take advantage of the situation both for the home and export trade, but this is not going to be done by continuing the methods which have been prevalent in the past. The German manufacturer owes his rapid advance in the export field among other reasons, to :—

1. The fact that he pursues by means of direct representation every avenue of trade available to him in foreign countries.

2. He is more approachable in the sense that he is willing to make materials to suit a given market.

3. His terms of payment are much more elastic than are common to us.

4. His literature is framed to suit the language and custom of the particular country whose trade he is attacking.

5. His prices, as a rule, are considerably lower.

If we are to reap any permanent advantage, some, if not all, of these methods, must necessarily be adopted, and we are not likely to make progress if we take advantage of the present situation to increase prices and to make conditions of payment abnormal. Examples of such are deserving of special attention. An illustration of such methods occurred the other day to a prominent firm of shippers, whose orders most people would welcome

under any conditions, but the execution of an order placed before the War was refused by a certain manufacturer unless the cash was paid before delivery. The order had to be placed in this particular instance, but when the foreign trade revives, as it may do in the next three years, the recollection of such an incident may act in a manner detrimental to this country.

The patriotism needed from a business point of view is that which makes an earnest but quiet study of the situation and makes equally earnest efforts to obtain orders for this country, based on the supposition that the man who pays generally has something to say in the selection of his goods, and as to the manner in which they are offered to him.

One notices that the motto "Business as Usual" is used extensively just now, and if the situation is to be turned to our advantage it would appear that this motto is opposed in one sense, to what is really required. In other words, instead of doing business on our usual lines we need to do it on lines more adapted to the need of the time.

Yours faithfully,

H. H. THOMPSON

(Holophane Limited).

DEAR SIR, *Aug.* 31*st*, 1914.

In the interest of my colleagues and those who serve with me on Boards, Councils, and Committees, it has been suggested that I should make it clear that although my grandfather was a Russian, my father was naturalised an Englishman in 1850, while I was not only born in London, but also educated at King's College School, University College and the Cambridge University. My whole business career has been in Great Britain with the exception of short periods with British Colonies and Italy. The Big Blue Book gives these and other details in its biographical section, to which I may add, quite a number of my relations are serving with His Majesty's colours both with and without commissions.

I should not have troubled you with the above had not organised trade competitors endeavoured to harm the interests of the organisations with which I am connected, and I wish therefore to state that every employee of the Union Electric Co., Ltd., during the fourteen years of its existence, has been and is a British-born subject (with the exception of a Dutch stenographer whose appointment was due to her competency in English orthography and stenography, and three young men, two of whom stayed under six months, the third, who stayed longer, left 10 years ago), and the same applies to the majority of the Board of Directors.

Deeply as we all feel the sufferings imposed on our land and its brave defenders, by this insane outbreak of German militancy, I am sure no Englishman desires to take any unfair advantage due to the trade disturbance, and I for one would be very sorry to impose any hardships on any honest Austrian or German resident here, who had hitherto lived amongst us a friend and conscientiously carried out his duties.

I see very many names of German origin amongst the officers and past presidents of the Institution of Electrical Engineers; were they placed there for other than their good work for British Electrical Engineering?

Finally, many Britishers may, like myself, have to thank business acquaintances in Germany or Austria for their present care of loved ones; should we show ourselves less noble?

Yours faithfully,

JUSTUS ECK.

BRITISH SCIENCE GUILD.

EIGHTH ANNUAL REPORT.

The Eighth Report of the Annual Meeting of the British Science Guild refers to several matters of immediate interest just now. There is, for example, the address on "Science and the State—The Encouragement of Discovery," by Major Sir Ronald Ross, who points out the ludicrously small amount of money spent in the encouragement of research in this country. At the present moment when there is so much talk of capturing foreign trade, the authorities would do well to realise the years of patient effort and organisation which have enabled Continental nations to outstrip us in so many fields.

Sir William Patrick Byrne, speaking at the Annual Dinner, referred to "the striking and discreditable fact that the Government of this country habitually uses the services of scientific men, even the most eminent, without remunerating them." The causes of German progress lie deep. But one of the most potent of them has undoubtedly been the respect in which science is held throughout the length and breadth of the country. Let us take the lesson to heart.

10

The
ILLUMINATING
ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by
LEON · GASTER

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EDITORIAL.

War and the Men of Science.

The influence of the war on British industries is being much discussed in the technical and daily press. We are glad to see that the leading technical journals are taking a dispassionate and reasonable view of the situation.

It is inevitable that feelings of anger should be kindled in war time. But however much we may detest the insane military ambitions which have led to the calamity of a European war, we must not allow these feelings to confuse our judgment on scientific and industrial matters. In our last number we pointed out that much careful thought, enterprise and organisation will be needed to take advantage of the present situation. Mere animosity will not capture foreign trade. It would be foolish to underrate the skill and industry that has been devoted to the building up of German trade, and unjust to deny the benefit to the world of many foreign inventions.

All this is happily expressed in a recent editorial in the *Electrical Review* :—

" It will be a matter for everlasting regret if we are going to be satisfied with airy utterances from men who are overwhelmed by the sight of figures in millions, and whose only qualification to write on things in general lies in their lack of specialised knowledge. We venture also to suggest that it will be to our discredit if we thoughtlessly imagine that we are going to succeed in capturing German trade by giving vent to feelings of anger and malice. The electrical and engineering manufacturer or trader will be able to deal more effectively with the position by freeing himself both from the excessive optimism of the uninitiated and from the erratic policies of men in haste and anger."

These words will, we think, appeal to all business men in this country and particularly to those engaged in industries of a scientific nature. We have now to talk less and do more. We are glad to find that the leading firms in the lighting industry are showing enterprise and adaptability in meeting the new conditions, and we hope that the ultimate effect will be to stimulate not only British manufacture but British invention as well. It is common knowledge that most of the recent advances in lamps and lighting have been made abroad. Let us hope that in the future we shall see many forms of lamps not only made but *invented* in this country—and the inventors properly encouraged ?

Men of science, by whom the sadder aspects of the cleavage of international relations caused by the war are more fully appreciated than by the man in the street, ought now to make their voices heard. The pen, if thrust into the background by the sword at the present moment, is a valuable weapon of which our adversaries have not neglected to make full use. Their leading scientists, divines, and men of letters have been busy pleading the cause of their country. Would it not be well for some of our most distinguished scientists, men whose names are known and honoured throughout the world, to take up the pen and express the ideals for which this country is fighting ? In the midst of the turmoil of passion and prejudice, which is apt to obscure the real issues at stake and to chill the sympathies of neutral nations, sober weighty statements from men whom the world respects would be of incalculable value, and suitable arrangements should be made to give them wide publicity, both among our adversaries and in neutral countries.

It must always be remembered that any unworthy display of bitterness —any departure from the high and dignified attitude taken up by our statesmen—will not only endanger the good opinion of our friends but will assist the cause of our adversaries. We should like to see the same spirit observed in business relations, particularly in the case of those firms which, though of foreign origin, established themselves as manufacturers in this country many years ago and have a long and honourable record of useful service behind them. In another number we mean to deal in greater detail with these business relations. Meantime we hope those in the lighting industry

will take their cue from the recent official utterances on the question of foreign trade and patents, and remember the declaration of our statesmen that this is a just war—a war waged in defence of British honour, British interests, and British obligations—and not a war of spoliation. Both in business and on the battle-field we must bear ourselves now so that we shall have no cause for regret in years to come.

The Lighting of London in War Time.

During the past month we have interviewed several visitors from abroad, all of whom remarked how calmly London was regarding the situation. During the day there is little to suggest that we are at war. People go about their business as quietly as ever; it is mainly the occasional marching of recruits that recalls the situation to our mind.

But at night, owing to the inspections being undertaken by the War Office with a view to a possible visit from hostile airships, a great change has come over the City. Practically all the large illuminated signs have disappeared and a large proportion of the lamps in our streets have been extinguished or are burning under reduced pressure. As an additional precaution, obscuring bands have been painted round the tops of many lamps which allow the light to pass downwards into the street but block out the actual lamps from the view of anyone up above, thus rendering them almost invisible to airships hovering over the City.

Such spots as Trafalgar Square and Piccadilly Circus present a most unusual appearance; many of our leading thoroughfares (such as Oxford Street, where all the central flame arcs have been extinguished) are hardly recognisable. Needless to say that we all acquiesce in any precautions that the Government may believe to be desirable, and we feel sure that the military authorities will arrange matters so as not to cause any unnecessary inconvenience. So far it has been somewhat surprising to find how comparatively well things have gone in spite of the diminished illumination. People bear patiently with a diminution in light which is made necessary by the times and sanctioned by the law, but a similar change from motives of economy in peace time would have led to a great outcry. To the illuminating engineer the situation is full of interest. There have been those who contended that even in ordinary circumstances some form of obscuring band should be painted round the lamps so as to screen the actual source from the view of drivers and pedestrians. Now they have an opportunity of judging the effects of this device. Probably one reason why the diminished light has not proved so very inconvenient is that the glare from the street lamps has also been reduced, so that our eyes can make better use of such illumination that exists. It is noticeable, too, that at one or two corners where there were formerly a number of brilliant lights one can see one's way rather better than before; in the past the glare from these lamps has proved rather bewildering. On the other hand it must be owned that the complete cutting off of the lights in the upper hemisphere has rather a dismal effect, and it has always been assumed that a certain amount of light should be allowed to fall on the houses on either side of the street.

For the rest, we hope that, while taking all needful precautions, the authorities bear in mind the vital importance of artificial light to the community and the dislocation of business that its interruption entails. Let us trust that the time is not far distant when the shadow of war will lift and circumstances will justify a return to our normal lighting programme in London.

The Lighting of the Home.

This issue contains a special article on the lighting of the Home. It will be recalled that in the ILLUMINATING ENGINEER for December, 1912, we published under the title of "Light and Illumination; their Use and Misuse," a series of simple general recommendations on Illumination. In the present article we apply some of these rules to Domestic Lighting.

In the first place it is hardly necessary to say that good lighting is essential in any properly-equipped home—a necessity, not a luxury. In any house, large or small, the expenditure on illumination is small in comparison with the comfort derived from it, and invariably forms only a minute fraction of the total amount of money spent on the building, furniture and decorations. People are sometimes inclined to economise in their lighting. At the present moment, owing to the difficulties caused by the war, they are perhaps particularly disposed to do so. A step of this kind is not true economy but a waste, which revenges itself in many ways. It diminishes the comfort and pleasure of the home, reduces the efficiency with which the work can be carried out, and is an occasional cause of accidents. Not only does a poorly lighted house make an unfavourable impression on visitors, but leads to neglect in many things; if a room is not properly illuminated it will not be kept thoroughly clean. Dust is apt to accumulate on the furniture, and the "life" of many useful articles will be shortened by neglect. All these are matters which would be confirmed by the lady of the house. In the dining and drawing rooms, which are mainly used at night, artificial lighting is now regarded as a most important item, but in the kitchen and the servants' quarters it rarely receives the attention it deserves. It is sometimes forgotten that articles subsequently used in the full illumination on the dining room table should be cleaned and prepared under an illumination at least as strong. In the kitchen, scullery and pantry, therefore, good illumination is needed, quite as much as in the dining room and the reception rooms.

Finally, it should never be forgotten that the home is the rearing place of the child. It is in the home and the school that the destiny of future generations is mainly decided. Educational authorities are now devoting much more care to the natural and artificial lighting of schoolrooms and the illuminating engineering movement has done much to foster their interest in these matters. But it is not enough to secure good illumination in the school if a child is allowed to read in badly lighted corners in the home and becomes accustomed to indifferent illumination in the nursery. If children come to view with indifference lamps covered with dust and placed in the wrong positions, mantles dropping from their supports before they are renewed, and shades which besides being unsuitable are only cleaned at the rarest intervals, they may carry this neglect into their own homes when they grow up and so the evil is perpetuated.

It is of course possible that military requirements may make it necessary for the lighting in private houses to be temporarily diminished. But until such a contingency arises (and we trust that it is remote) we hope that the lighting industry will continue its efforts to secure improved illumination. It is difficult when the mind is distracted by more exciting events to keep one's attention focused on these everyday matters. But it is a duty none the less, attention to which will be well repaid in the future.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

THE LIGHTING SCHEME AT THE PANAMA-PACIFIC EXHIBITION.

BY AN ENGINEERING CORRESPONDENT.

THE war has distracted attention from the projected Panama Exhibition to be opened next year. From a number of articles that have recently appeared in the United States it would appear that many of the methods of lighting will be of quite exceptional interest, and in this article a brief account of them will be given.

According to a recent contribution by W. H. F. N. de Bille,* there will be three main methods employed: "flood lighting," "jewels," and the "scintillators." Whereas at former Exhibitions the invariable method has been to outline the chief architectural features in incandescent lamps, the attempt is now to be made to flood the frontages of buildings with white light from concealed lamps and to accentuate the natural shadows by the use of purple-dipped lamps (also concealed). Spaced round the white buildings there will be high ornamental standards bearing from one to thirty lamps. The lamps will only be exposed on the sides facing the buildings. The remote side will be concealed from view by metal banners. Thus at a short distance away the observer will see the illuminated buildings only, not the source.

A "TOWER" OF JEWELS.

In addition, hundreds of thousands of special hard glass polished "jewels" are to be mounted on the faces of certain buildings (the Tower of Jewels is entirely covered by them), and these jewels will glitter in the rays of a number of searchlight projectors.

In the garden of the Exhibition the art of lighting by concealed sources will also be much used, full advantage being taken of the screening effect of foliage for this purpose. As evening advances the lights will be gradually turned on according to a predetermined plan, a gradual transition from the appearance by daylight to the entirely distinct night-effect being aimed at. It is also stated that a climatic peculiarity of San Francisco will be turned to account. Every night, with the sinking of the sun, great fog-banks roll up and remain suspended two or three hundred feet above the bay

* *Gas World*, May 16th, 1914.

and the city. These clouds will form an excellent background for a series of coloured searchlights whose beams will be gradually intensified as evening draws on.

Huge Gas Flambeaux.

The lighting will be mainly electric, but in the "Court of Abundance" high pressure gas will be employed and giant flambeaux, with flames of ignited gas reaching to a height of 15 feet, are to surround the central basin of bubbling water. It is stated that in this court an attempt will be made to express symbolically the creation of the universe, and in which two elements, fire and water, will be the dominant features.

In a paper recently read before the San Francisco Architectural Club by Mr. J. W. Gosling* some additional particulars are given of the illumination in the various courts. Thus in the Festival Hall and the surrounding smaller conference rooms semi-indirect lighting will be largely used and the main entrance halls will be illuminated by very large suspended fixtures composed of a dish of leaded glass. Both direct and indirect lighting will be used in the main auditorium. The indirect is provided by searchlights set in a well in the centre of the room, the light being directed upwards through a diffusing glass plate on to the inner surface of the great central dome. But in order to remove any impression of flatness there will be six ornamental ball-fittings in the arches over the balcony as well as the wall-fittings round the corridors at the rear of the balconies. These fittings, while intended to relieve the somewhat flat effect of unaided indirect lighting, will be toned down to give a soft and mellow light.

In the California Building some striking fittings are to be employed. The oval entrance stairways will have newels composed of three figures, each bearing luminous glass balls. In the President's dining room there is a skylight, and suspended below it a silk curtain through which light will filter into the room. The arcades and forecourt adjacent to the building will be lighted by small lanterns, many of them concealed in the hedges and foliage.

* *Journal of Electricity, Power and Gas*, April 11th, 1914.

Illuminated Columns and Fountains.

In the Court of the Universe the main source of light will be placed in the two fountains at the end of the sunken garden. The part giving the light is in the form of a column in the centre of each fountain. These columns consist of heavy diffusing glass and each contains ninety-six 2500 c.p. half-watt lamps. It is calculated that the brightness of the face of the peristyle will be about 3 ft.-candles. Another device in this court is a ring of figures bearing stars of jewels. In the base of each figure is a projector, invisible from below but casting a beam of light across the court so as to illuminate the star held by the figure opposite to it.

The architectural scheme of the Court of Abundance is unique and calls for special lighting devices. The basin in the centre is to have at one end of it a fountain in the form of a globe, surrounded by figures. This globe is 18 ft. in diameter, will be built of glass, and is provided with a mechanical arrangement which will give the effect of the globe turning on its axis. Streams of water will pass over it, and from the sides clouds of steam will issue, thus giving the effect of the Earth revolving in space. At the opposite end of the pool will be the Sun, setting at the water's edge. This sun is formed by a disc of plate glass about six feet in diameter and has behind it a series of small incandescent projectors driving a powerful light on the Earth at the further end of the pool. By the use of coloured shutters the effect of sunset can be imitated. As mentioned above, huge gas flambeaux will also be used in this court, and it is said that the colour of the flames will be altered from time to time by throwing into them salts of barium, sodium, strontium, &c.

The Great Dome of the Palace of Horticulture.

Finally, in the Palace of Horticulture a new and highly ingenious piece of lighting apparatus is to be used. The arrangements are thus described in a recent number of the *Electrical World** :—

The palace of horticulture at the Panama-Pacific International Exposition

* April 11th, 1914.

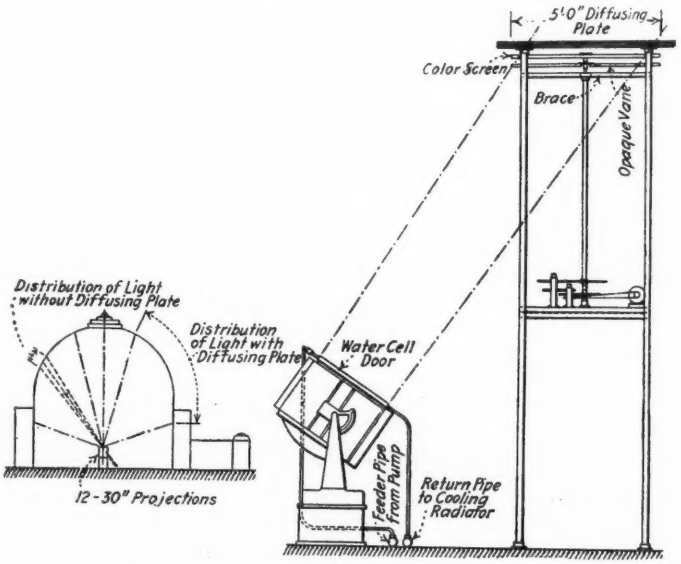
to be held at San Francisco next year will be built almost entirely of glass and will be surmounted by a dome 150 ft. high and 152 ft. in diameter of similar construction. To illuminate this dome from the interior and to make it one of the feature spots of the exposition sixteen 30-in. searchlamp projectors will be placed in a circle about a column at the centre of the dome. At the top of this column, as shown in the accompanying sketch, will be mounted a colour screen of six segments, an opaque vane which will cover two segments at the same time, a lens and a diffusing plate.

The segments of the colour screen will be of red, green and yellow. The screen will revolve at the rate of 500 r.p.m. and the vane at the rate of 499 r.p.m., thus enabling the screen to make one full revolution a minute more than the opaque vane.

The rays of the searchlamps will be thus focused on the screen and diffused on to the dome, the revolutions causing the various colours of the spectrum to illuminate the glass.

A combination of three lenses will be used, so arranged that only one will be in position over the screens at one time. One lens will be composed of a number of tiny lenses which will have the effect of producing "spots" of light upon the dome. Another will be plain. The third will produce the most spectacular effect of all, presenting the appearance of countless tiny tadpoles squirming about the interior of the dome.

As far as one can judge from the preliminary reports, therefore, the lighting of the Exhibition will be something quite unique and remarkable, and will be awaited by lighting engineers with keen interest.



ERRATUM.

Through a printer's error, which occurred after the final sheet had been passed for press, the diagram on page 440 in our September issue was inadvertently printed upside down.

THE LIGHTING OF LONDON.

READERS will recall that in our March issue there was a special account of "The Lighting of London" in which statistics were quoted showing how the intensity of the illumination had increased within recent years. We have since received from Mr. W. J. Liberty (Public Lighting Inspector in the City of London) some further particulars of various streets in London, which show even more clearly what an enormous change has been made.

Date.	Thoroughfare.	Type of Lamp.	C.P.	Increase.
1905	**Fleet Street**	Upright burner posts on footway. Low pressure.	(abt.) 3,600	
1908	**Fleet Street**	7-ft. brackets on house fronts. H.P. at 54-in.	(abt.) 24,000	(abt.) 20,400
1913	**Fleet Street**	Centrally hung. H.P. at 90-in.	(abt.) 28,000	(abt.) 4,000
1892	**Cheapside and Poultry** ..	Open arcs on posts on footway	(abt.) 9,800	
1913	**Cheapside and Poultry** .. (*Half of these are turned out at midnight.)	Centrally hung. Oliver-Electric Flame Arc with Dioptric Lenses.	*(abt.) 48,000	(abt.) 38,200
1900	**High Holborn**	Low pressure gas, upright burners on columns on footway	(abt.) 1,105	
1912	**High Holborn**	High pressure gas, on columns on footpath	(abt.) 10,800	(abt.) 9,695
1900	**New Oxford Street**	Low pressure gas, upright burners on column on the footpath.	(abt.) 2,145	
1912	**New Oxford Street**	High-pressure gas on column on footpath	(abt.) 26,400	(abt.) 24,255
1900	**Tottenham Court Road Circus**	Low pressure burner on column on rests	(abt.) 1,260	
1912	**Tottenham Court Road Circus**	High pressure on rest	(abt.) 3,600	(abt.) 2,340
1910	**Victoria Street, Westminster**	57 low pressure gas lamps on columns on footway	(abt.) 9,075	
1914	**Victoria Street, Westminster**	24 columns on footways, high pressure gas	(abt.) 43,200 (nominal 60,000)	(abt.) 34,125

Date.	Thoroughfare.	Type of Lamp.	C.P.	Increase.
1890	**Queen Victoria Street** ..	92 flat flame gas lamps, chiefly 5 cub. ft. per hr.	1,774	
1892	**Queen Victoria Street** ..	30 open electric arcs	21,000	
1905	**Queen Victoria Street** ..	42 gas lamps, upright Keith burners 10″ pressure, 20 cub. ft., 600 candles	25,200	Increase in nine years, 59,800 (over 200 per cent.)
1914	**Queen Victoria Street** ..	42 high pressure (90″) Keith inverted lamps.	84,000	

The figures given for Queen Victoria Street are very striking. The present candle-power is practically 50 times as much as in 1890, when flat flame burners were used, and even in the last nine years the light has been trebled.

Finally, Mr. Liberty has attempted to estimate the total candle-power of the lamps in use in the Metropolis in 1844. He finds that there were 30,400 lamps carrying iron batswing burners, most of which burned 5 cub. ft. of gas per hour, and gave, possibly, 2½ candles per cub. ft. This gives a total candle-power of 380,000 for the whole Metropolis. Contrast this with the lighting to-day, when in the one square mile of the City alone the total candle-power adds up to 1,270,160 !

ILLUMINATING ENGINEERING SOCIETY (U.S.A.). EIGHTH ANNUAL CONVENTION.

(Held at Hollenden, Cleveland, September 21st—25th, 1914.)

THE following list of papers was arranged for the above Convention, and we hope to refer to some of these in THE ILLUMINATING ENGINEER shortly :—

" Factory Lighting." By Hogue and Dicker.
" Some Experiments with the Ferree Test for Eye Fatigue." By J. R. Cravath.
" Planning for Daylight and Sunlight in Buildings." By Marks and Woodwell.
" Notes on the Ulbricht Integrating Sphere and Arc Lamp Photometry." By H. K. Chaney.
" Effect of Room Dimensions on Efficiency of Lighting Systems." By Ward Harrison.
" Relation of Light to the Critical Inspection of Documents." By A. S. Osborne.
" Experiments with Coloured Absorbing Solutions for Use in Heterochromatic Photometry." By H. E. Ives and E. F. Kingsbury.
" A New Standard Light Source." By L. A. Jones.
" Artificial Daylight—Its Production and Use." By M. Luckiesh and F. E. Cady.
" Characteristics of Gas-Filled Lamps." By G. M. J. Mackay.
" A Transmission and Absorbing Photometer for Small Areas." By Nutting and Jones.
" Recent Improvements in Gas Lamps." By A Welsbach Representative.
" Illumination of Light Shafts." By C. H. Sharp.
" Portable Mine Lamp." By H. H. Clark.
" Some Recent Experiments on Vision in Animals." By H. M. Johnson.
" Light Filters for Use in Photometry." By C. E. K. Moes.
" The Locomotive Headlight." By J. L. Minick.
" Present Practice in Machine-shop Lighting." By Powell and Harrington.
" The Development of Daylight." By E. J. Brady.
" Lighting of the Home." By a Representative of The Duquesne Light Company.
" Lighting of a Carpet Mill." By Rose and Ockley.
" Colour Variation in Illuminants." By Jones and Nutting.
" Reflection Standards." By Nutting and Jones.
" Physiological Effects of Light on the Body." By E. C. Titus.

LIQUID AIR AND NEON LIGHTING.

By an Engineering Correspondent.

One of the most interesting applications of liquid air in industry promises to be the extraction of neon, and its utilisation in lighting schemes. M. Claude, the well-known French engineer, who has been experimenting in this direction, claims that the neon tubes, as made by him, will far surpass in economy and effectiveness the nitrogen tubes, that have hitherto been used. The neon is extracted as a bye-product in M. Claude's process for liquefying air, and producing from it pure oxygen and nitrogen. This process, it will be remembered, replaces that of Linde. Liquefaction in both cases is effected by utilising the counter-current exchanger and the Joule-Thomson effect of cooling by expansion through porous plugs, but in Claude's apparatus, an arrangement for fractionally condensing the air and rectifying it with liquid nitrogen as it evaporates, enables him to obtain nitrogen and oxygen in almost any degree of purity.

The importance of the process may be gauged from the fact that with it nitrogen at 99·9 per cent. purity is produced at a cost of 2¼d. per lb.; oxygen at 98 per cent. purity may be had at a cost of $\frac{1}{10}$d. per lb.; and neon is extracted from the standard apparatus to the tune of 25 gallons per day. The separation, owing to the low boiling-point of neon, is fairly easily effected at scarcely any increase in the cost of the main process. M. Claude therefore has set about finding a use for his somewhat strange bye-product and, inspired by an experiment of Sir William Ramsay's, has turned his attention to lighting. It was found at once that only one-third of the potential necessary in a nitrogen tube was required, but two difficulties were encountered. One was the colour, a somewhat vivid red, which caused all blue objects to appear black; the other was the fact that the slightest traces of foreign vapours given off by the electrodes carrying the current to the tube, totally destroyed the luminous power of the gas.

The first difficulty has been overcome by the use of correcting tubes containing mercury, it being found that the mixed light of mercury and neon is approximately "white." To deal with the second obstacle, ingenious use has been made of the discovery of Dewar, that at low temperatures carbon acts towards gases as a strong absorbent. With gases of low boiling point the absorbing power is less. Hence it was found that, if the neon tube which was to be purified was connected to a vessel immersed in liquid air and containing carbon, the impurities given off by the electrodes were slowly absorbed, while the neon was left intact.

The success of this device left no obstacle in the way of producing neon tubes for commercial use, and installations have in fact been carried out, on occasions of festivity, at the Grand Palais des Champs-Elysées and at the Church of Saint-Ouen at Rouen. As the luminous intensity of the tubes is four times greater than with nitrogen and the power consumption 0·6 watts per c.p. against 1·7, it would seem that the new light has a future before it.

PHOTOMETRY OF LAMPS ENCLOSED IN CONCENTRATING REFLECTORS.

The question has often been raised whether lamps equipped with highly focusing reflectors can be treated as "point sources"—*i.e.*, whether at moderate distances the inverse square law would apply. Some recent researches in the United States by E. J. Edwards and W. Harrison suggest that this is the case, and that in general the error due to "parallelism" is negligible.

SHORT NOTES ON ILLUMINATING ENGINEERING.

THE USE OF SMALL FLASHLIGHTS FOR ARMY SIGNALS.

THE use of arc lights for signalling purposes is of course quite familiar, but it seems that the coming of the low voltage metal filament lamp has led to a new form of portable flashing signal. A recent number of *Popular Mechanics* describes their use in the German Army as follows :—

"Satisfactory results have been attained in experiments made by the Signal Corps of the German Army with an optical night-communicating device consisting of a small electric searchlight mounted with field glasses. The current for the light is supplied by dry batteries strapped to the belt of the operator. The light rays converge slightly so that they are invisible excepting in a certain plane. By the use of code messages may be transmitted quickly and silently to a distance between five and six miles. The arrangement may also be used at shorter range during the daytime. Another apparatus, especially designed for the transmission of messages between aerial scouts and land forces stationed at specific points, is composed of a reflector

and an electric lamp with a telescope mounted on its upper rim. A push button on the handle provides for the flashing."

PRIVATE AND PUBLIC LIGHTING IN WAR TIME.

IN our last number we referred to some of the special lighting appliances used in war, searchlights on land and sea and even in the air, portable lamps for field hospitals, &c.

A rather unexpected effect of war is to be found in the instructions issued to certain towns to extinguish their public or private lighting. For example, the Secretary of the Admiralty in Great Britain has issued the following statement :—

"For the general safety of the community, the country being at war, municipal authorities are requested to reduce as much as possible the number of powerful electric lights on piers, esplanades, and public places which are visible from seaward or from the air."

It is also reported that in Paris all lights are extinguished at an early hour in the evening with a view to minimising the danger of bombs from aeroplanes. On the other hand, it is stated that in captured towns in Belgium the Germans insisted on lights being kept burning throughout the night in order to make it more difficult for people to shoot from the windows without detection.

More recently instructions have been issued in London for all prominent lights to be extinguished, and besides shop fronts, signs, &c., many streets have been left in partial darkness. This is stated to be desired by the military authorities in order to facilitate some experimental inspections of the city by a British airship.

The diminution in illumination has already made a great change in the appearance of the streets by night, and should not be carried too far ; otherwise there may be a crop of accidents due to motor vehicles not being able to see their way distinctly, especially if they travel at their usual speed.

Motorists have also a duty to consider, as the following extract from a recent issue of a daily paper shows :—

"In these days of darkened streets something ought to be done to prevent the use of powerful headlights on motor-cars. In traffic they are dangerously dazzling to drivers, and in the past few nights I have seen some very near escapes and taxi-drivers are complaining bi'terly. 'Lighthouse' motor lamps are not fair in dark traffic-ridden streets. Motorists, please note."

SCHOOL LIGHTING.

A PAPER on the above subject, read by Dr. E. H. T. Nash before the Medical Officers of Schools Association,* has been reprinted in booklet form, together with the discussion.

Dr. Nash reproduces a number of plans of British and Continental schools, showing how the requirements as regards daylight are met, making special mention of some schools designed by Mr. Widdows in Derbyshire. On the whole, Dr. Nash thinks that in this country left lateral lighting is the ideal to be aimed at.

Frequent reference is made to the investigations of the Joint Committee appointed by the Illuminating Engineering Society to deal with school lighting.* Some interesting photographs and data are given, bearing on the lighting by gas of a school near London. The substitution of inverted incandescent burners enabled an illumination of 3·5—5 ft.-candles to be obtained with a consumption of 24 cub. ft. of gas per hour ; as compared with only 0·7 ft.-candles and a consumption of 40 cub. ft. per hour with the old inefficient gas flat flame burners—a result that shows how much can be achieved by means of modern illuminants.

* See Report, ILLUMINATING ENGINEER, July, 1914.

OUTSIDE SHOP LIGHTING.

THIS photograph of a shop, lighted by a series of flame arc lamps, is an interesting example of a "snap shot" by artificial light. It is only in the case of an exceptionally brilliant illumination that a short enough exposure to include people in the photo is possible.

The kind of lighting shown here is open to objection from the illuminating engineering standpoint. The brilliant lamps, hung at such a low level, are apt to trouble the eyes of passers-by and cause distraction to traffic. At the present moment citizens are being asked to shield or extinguish all exceptionally brilliant lights owing to the inspection of London from above by an army airship. Quite a number of shops are said to have already adopted shades throwing the light into the window but screening the lamps from view. Thus military requirements are bringing about a change which illuminating engineers have long recommended !

SCHOOL CONDITIONS AND EYESIGHT.

IN his final report as school medical officer for Sheffield, Dr. Ralph Williams gives two instances of things they do better abroad. Thus, he points out that in Sheffield the school windows are cleaned four times a year irrespective of the situation of the school, whereas in Germany and Switzerland school windows are cleaned twice a week. Later he mentions that the incidence of Myopia amongst Swedish school children has been reduced by 30 per cent. by allowing not more than 40 minutes' consecutive work, with an interval of 20 minutes' play. This fact he commends to the attention of education authorities in this country. —*The Medical Officer.*

THE LIGHTING OF WIDE THOROUGHFARES.

IN a recent article in the *Gas World* the lighting requirements of a road 75 feet wide are considered. It is contended that in general a wide thoroughfare should be lighted by lamps placed near the kerb, and that centrally placed street lamps are a mistake.

The effects of lighting a wide road from the centre are :—

(A) To waste a great portion of the light on the tops of passing cars and the central portion of the roadway which can be little used for general traffic.

(B) To make the footpath, which should be the best, the worst lighted portion of the thoroughfare.

(C) To afford the minimum portion of the quantity of light provided to the shopkeeper.

(D) To throw a passing shadow on or towards the footpath from every moving vehicle.

(E) To throw a shadow on to the footpath from every standing vehicle.

(F) To minimise the light available on the kerb line.

(G) To light the wrong side of the tramcar and throw into shadow that side upon which passengers alight from and board the car.

THE MEASUREMENT OF DAYLIGHT BY PHOTO-ELECTRIC CELLS.

THE researches on daylight illumination in schools, &c., recently dealt with in this journal, revealed the need for some satisfactory apparatus capable of recording automatically the variation in visible light. Many devices have been used to record fluctuations in solar radiation, but it has always been open to question whether such instruments measure exactly what is seen by the eye.

From this standpoint the alkali-cell of Elster and Geitel, recently applied by Dr. W. Voege to photometric tests in the laboratory,* seems to have possibilities. According to a note in the Elektrotechnische Zeitschrift,† this apparatus can, by a slight modification, be applied to measure daylight successfully, and it is expected that it will not only be useful in meteorological researches, but will also prove valuable in experiments on the effect of light on plants and animals. Considering how deep-seated must be the effect of daylight on human life, a convenient recording apparatus of this kind would seem to have great experimental possibilities.

The Elster and Geitel cell responds readily to visible radiation, and is stated to be very suitable for recording instantaneous light-values, *e.g.*, for tracing out the fluctuations in daylight in the course of the day. In the ordinary course of events one uses with the cell a milli-ammeter. But if, instead of this, an instrument termed a "hydrogen coulombmeter" is used, the current flowing through the circuit at any moment is exactly proportional to the intensity of the light and the separation of hydrogen in the course of the day is therefore proportional to the total light radiation received (Hefner-hours). In this way a mean value for daylight, independent of temporary fluctuations is readily obtained.

* Illum. Eng., Lond., Vol. VII., 1914, p. 295.
† E.T.Z., July 9th, 1914.

AUTOMATIC EXTINCTION OF STREET LAMPS.

THE use of the selenium cell for such purposes has also attracted attention and we notice in the *Electrical Review** an account of a device adopted by Mr. C. J. Turner, electrical engineer at Hoylake, to turn on and off street lamps at the proper times. For this purpose he uses a selenium cell and relay. So long as the daylight lasts the resistance of the selenium cell (which is connected to the relay in circuit with the street mains) is low enough to allow sufficient current to operate the relay, which keeps the lamp switch open. But when the light falls the resistance of the selenium cell increases; eventually the relay drops, the switch is closed, and the lamp lights up. It will be observed that a temporary fog would act in the same way. The lamp is automatically lighted when the light is bad. The cell and relay are mounted in the switch box at the top of the pole. By adjusting the relay the sensitiveness of the apparatus can be altered and it can be made to respond to any desired diminution in light.

It is stated that some of these devices are already being used experimentally at Hoylake, and the results are found to be quite promising.

* May 15th, 1914.

THE LIGHTING OF THE HOME.

In these days a great deal is written on the cost of domestic lighting. The consumer is encouraged to make use of the latest and most efficient lamps, and he can now obtain far more light for a given consumption of gas or electricity than would have been possible a few years ago.

But it should also be understood that the light obtained needs to be used wisely and well—that a lamp misplaced is a lamp wasted. It is true that taste plays an important part in domestic lighting. In the houses of people of moderate means cost and utility are the chief considerations, while in the homes of the wealthy the choice of fixtures may be guided chiefly by the desire to produce an artistic effect.

Yet there are certain practical considerations that apply equally to all domestic lighting. Everyone cannot afford expensive fittings, but adequate illumination is always worth paying for. A poorly lighted house is invariably badly looked after. Dust is allowed to collect on the furniture, things are apt to fall into disorder. An under-lighted gloomy house has a forbidding and depressing effect, a properly illuminated one creates a cheerful impression and appears at its best.

Another point to be noted is that the lighting should be well under control. It may cost a little more initially to have plenty of plugs and switches for electric light or to instal apparatus enabling gas lamps to be controlled from a distance, but the convenience of such arrangements fully repays the first cost. It must be remembered, too, that with an inadequate number of switches lamps will necessarily be left burning when they are not needed, which leads to waste. On the other hand, if the lighting be properly subdivided it will often be possible to manage with only a few of the lights on, and thus to make economies which will more than counterbalance the initial expense.

Let us now consider some of the chief points to be attended to in a well lighted home. The most convenient method of dealing with the various problems that arise is to start at the entrance to the house and then to take up in turn the lighting of each room (hall, dining room, drawing room, &c.).

Light Outside the Front Door.

The first point that deserves notice is the provision of a suitable light outside the front door. The light should be placed above the doorway and well shaded from the eyes of the person opening the door. Such a light serves to guide the steps of the departing guest or to scrutinise callers before admission. It may be suggested that a light strong enough to give at least 2 foot-candles on the doorstep might well be used. This would probably require a lamp giving at least 50 candles, and equipped

with a suitable concentrating form of reflector. It is worth while noting that a well-whitened doorstep is much more readily seen than one which is about the same tint as the path outside. In order to reveal the step and prevent the possibility of people stumbling, *contrast* is the most important factor.

Lighting up the Name of the House.

The name or number of the house should also be illuminated by night. In the case of many houses the name is indicated on the glass above the front door and is lighted by the lamp in the hall behind. But in order to be clearly seen the name ought to be backed by some form of diffusing glass, giving a good luminous background. Not infrequently one finds that the names of houses are left in complete darkness. Anyone who has attempted to locate an address in an unfamiliar neighbourhood will appreciate the need for some systematic method of lighting.

The Hall.

By the "*hall*" is sometimes meant merely a small lobby containing rack, umbrella stand, &c. In this case lamps of moderate candle-power, giving a general illumination of about 2 foot-candles would probably suffice. The walls should preferably be light in tint so as to diffuse the light thoroughly into all the corners of the room making all hats and coats readily distinguishable. In a badly lighted room there is sure to be trouble in finding such garments and they are apt to become dusty.

The source of light should be screened by a suitable diffusing globe or reflector. The heavily obscured "antique" lanterns not infrequently employed in such cases absorb a great deal of light and should only be used with discretion.

In halls of a more imposing character one's choice usually rests between chandeliers and globes or inverted bowls hung from the ceiling. Properly applied semi-indirect lighting seems to be well adapted to such interiors, since there are usually objects on the wall which require a fairly strong illumination. However, the system of lighting must naturally be adapted to the architectural scheme of the interior and this may demand the use of chandeliers. In old mansions there are not infrequently massive antique fittings and the conversion of these to gas or electricity calls for considerable skill. It is very desirable to avoid low-hanging chandeliers with unscreened brilliant lamps such as are inclined to dazzle the eyes and throw inconvenient shadows. Such lights should be screened by suitable shades, or, if miniature electric lamps are used, the bulbs should be frosted.

The Drawing or Reception Room.

In a *drawing room* individual taste naturally plays an important part. The type of lighting employed varies according to the style of the room and the uses to which it is put. Some people, who entertain a good deal, like to have the room flooded with light. They require a "cheerful" illumination and are anxious that all the pictures, china or other treasures in the room should be fully displayed.

Others prefer a "cosy" and subdued system of lighting, making use of silk shades in preference to cut glass, &c. Sometimes, even when the room as a whole is brightly lighted, there are little curtained alcoves that can conveniently be treated separately, forming "a room within a room" where people can retire for a confidential chat.

Lumina Bureau Photo.

Main Hall lighted by chandeliers, each carrying four small candle-power completely frosted lamps.

Lumina Bureau Photo.

Drawing Room lighted by central semi-indirect unit and small candle-power shaded bracket lights. Silk-shaded lamp in alcove.

An arrangement that answers well in many drawing rooms is to have a central semi-indirect fitting supplemented by wall brackets. The latter should, above all things, be well screened so as to give a soft light, for they almost inevitably come within the range of vision. Lamps of 10—15 candles would answer best in these circumstances.

In most cases the best plan would be to provide various alternative systems of lighting so as to meet all demands. For example, the central fitting may be equipped with several lamps separately controlled so that either a brilliant or subdued light can be obtained. There may also be well shaded bracket lights or portable standard lamps carrying silk shades. In the ordinary course these may provide all the light that is necessary, but when there is company the central fitting can be turned full on. An illumination of 3—5 foot-candles would probably be ample.

One advantage of the semi-indirect central fitting is that the light, being reflected from the ceiling in all directions, comes over the shoulders of people reading round the fire, whereas people in this position would naturally hold their books in the very worst position to receive light from the wall-brackets. It is an old and sound rule "not to read facing the light." In order to avoid the consequence of breaking this rule adequate illumination from the central fitting is needed and any wall bracket fittings should be well shaded so as not to annoy the eyes.

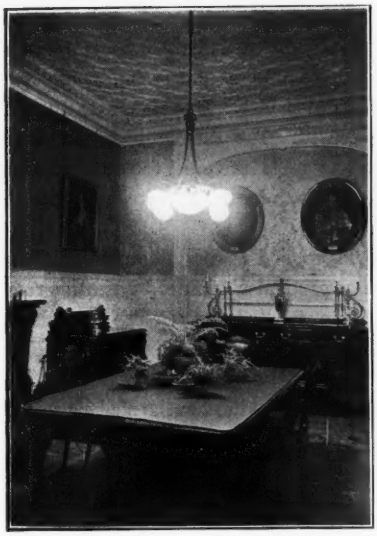
Many drawing rooms open out into verandahs. These may be lighted by tasteful fittings hung from the roof and then provide an excellent place for reading on summer evenings, as well as giving a cheerful effect when seen from the garden.

The Dining Room.

In the *dining room* the table is usually the chief centre of interest and it is customary to provide a strong illumination thereon, leaving the rest of the room in a relatively subdued light. The table is often illuminated by a lamp in a silk shade. This may enclose an appropriate translucent reflector, throwing most of the light downwards, but allowing some to pass out and illuminate the shade, giving a pleasing effect. The shade should be hung at such a height above the table that it does not interfere with the view of people looking across the table, and the shade should be just deep enough to screen the light from the eyes of people facing it; it should, however, not enclose the lamps so completely as to prevent the more remote parts of the table being illuminated.

The illumination on the table may be 3—5 foot-candles, but one or even half a foot-candle would probably suffice for the rest of the room. To provide this a central cluster of lamps on the ceiling, in conjunction with the shaded lamp, may be used. This combination is a common one in middle-class houses.

In larger rooms more elaborate chandeliers carrying cut-glass globes, or crystals, may be used. Much depends on the purpose which a dining room serves. Not infrequently it is used by people for reading and writing and it is often convenient to have bracket lights on either side of the fireplace or outlets from which portable desk lights can be fed. Sometimes, too, there are pictures on the walls which require a higher general illumination than is usual with silk shaded lamps, and in such cases chandeliers carrying lamps in diffusing globes may well be employed. If the room is too large to be completely lighted from a central chandelier, lamps over the side-board should also be provided.



Lumina Bureau Photo.

Central chandelier carrying bowl and four surrounding globes.

Lumina Bureau Photo.

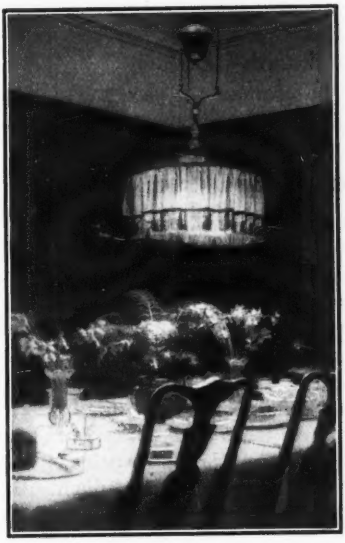
Central indirect light of novel pattern.

DINING ROOM LIGHTING.

The adjacent photographs show three distinct methods of lighting a dining room.

In the two upper views general lighting (giving, however, the strongest illumination on the table) is provided, but there is also sufficient light to show up the pictures on the walls.

In the other view we have the conventional strong lighting of the table, with subdued illumination for the surroundings.



Lumina Bureau Photo.

Conventional lighting by silk shaded central lamp and lights on ceiling.

Each room in a house presents its special problems. In a *boudoir* a soft well-screened cosy system of lighting is usually preferred. In the *billiard room* the lighting has become practically standardised. A full-sized table requires six symmetrically-placed lights of 50—60 c.p. each, completely screened by deep conical cardboard shades. By this means an even illumination of 15—20 foot-candles can be secured. The surroundings should be lighted in a subdued manner so as to make the table the chief centre of interest. Special illumination for the marker may be desirable, a local light screened from the eyes of players being used.

Various Rooms.

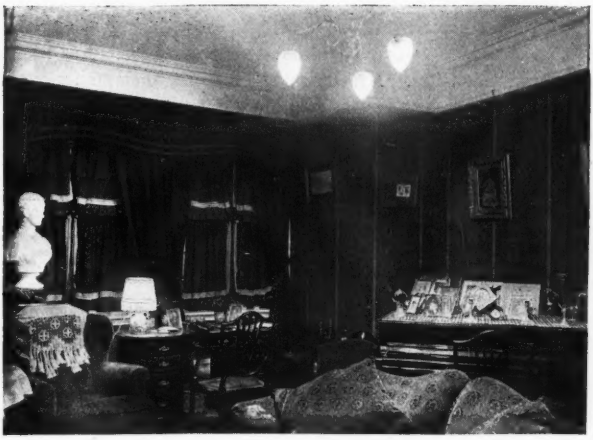
In the *library* the main essential is to provide a good reading illumination of not less than three foot-candles on the table, and it is particularly important in this room to see that the lamps are well shaded and do not appear "glaring." The light should also be well diffused so as to avoid inconvenient reflections from shiny paper. Here, again, the table should be more brightly lighted than the rest of the room, but it is necessary to allow sufficient illumination (say one foot-candle) for the shelves so that titles of books can be clearly read.

Landings, corridors and *stairs* only require enough illumination to enable people to see their way about in comfort. One foot-candle on the floor is usually sufficient, but on some landings more may be desired with a view to showing off the surroundings. On the stairs the screening of the lights is an important matter. Insufficient light may cause a person to stumble, but a strong light in his eyes may have the same effect. The essential point, therefore, is to equip the lamp with a shade throwing most of the light on the stairs, but screening the actual source from the eyes of anyone about to descend. When electric lighting is used it is convenient to control the lights on a landing by "two-way" switches, so that they can be turned off either from the top or the bottom of the stairs.

In a *bedroom* the place where light is mainly needed is the dressing-table. Two well-shaded lamps, on either side of the mirror should be provided, so that the face of anyone standing at the table receives light from several different directions. A single lamp is sometimes used but this is not satisfactory, as there is a tendency for part of the face to be left in complete shadow. The room as a whole should also be well lighted. A person dressing likes to examine his full length appearance in the mirror. A lady, for example, may wish to judge of the effect of the dress she is wearing, which will subsequently have to stand the brilliant illumination in the ballroom, and should therefore be well-lighted in the bedroom as well. It is hardly possible for a person standing in the centre of the room to receive adequate illumination from the local lights over the dressing-table, and a good central outlet would often be appreciated. In addition, a light over the wash-stand is desirable, and there should also be an outlet by the bedside for a portable lamp capable of being readily turned on during the night if need be.

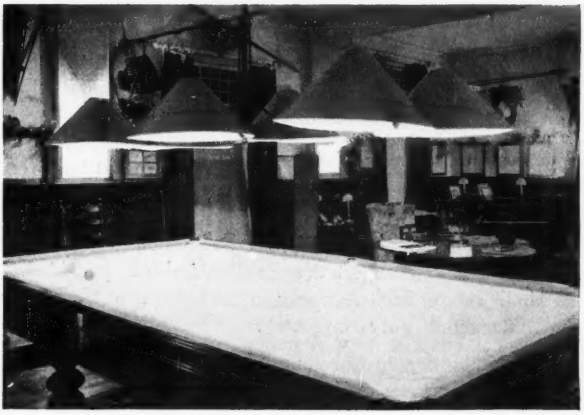
Bedrooms.

The necessity for good illumination in the *bathroom* is evident. Materials which will withstand a steam-laden atmosphere should of course be employed. It is now becoming usual to employ white tiles or a light distemper on the walls, which materially aids the illumination. As a rule the bathroom, being comparatively small in size, can be lighted by a single central outlet.



Lumina Bureau Photo.

Boudoir.—Central chandelier carrying three lamps in diffusing globes. Small shaded writing lamp on table.

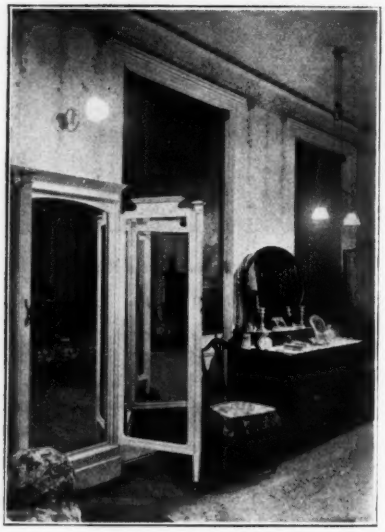


Lumina Bureau Photo.

Billiard Room, showing usual six-light arrangement for tables, with conical cardboard shades. The illumination for the surroundings is subdued, but there are a number of bracket lights which enable people to see their way about in comfort.

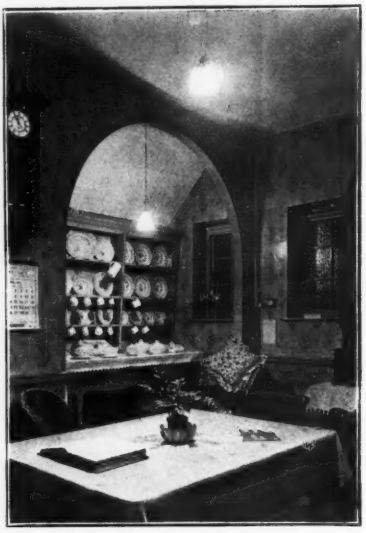
Next let us take the *kitchen*. There is a close connection between illumination and cleaniness, darkness and disorder. The lighting of the kitchen, therefore, deserves special care. It is clearly unreasonable to expect silver and dishes placed in the full blaze of light on a dining-room table to look nice unless they can be cleaned and arranged under an equally good illumination. Moreover, the kitchen in the average middle-class home is used by the servants for many different occupations. Cooking is done on the range and oven, dishes are laid out on the table, and reading and sewing may fill up the evening. The chief points where light is required are the ovens, the table

Kitchen, scullery, pantry, &c.



Lumina Bureau Photo.

Bedroom.—Two adjustable shaded lights over dressing table. Special light over full length mirror.



Lumina Bureau Photo.

Kitchen.—Adjustable shaded light over table, special light over dresser.

and the dresser. An adjustable pendant over the table is very useful, being lowered when fine work is to be done and raised when the illumination is wanted all over the room. A local light to illuminate the dresser should also be provided.

Somewhat similar considerations apply to the lighting of the *pantry* and *scullery*, and even the *coal cellar* should not be forgotten.

Lastly, good illumination in the home is essential *in the interests of the children*. The illumination of the nursery should be managed with special care. Educational authorities have been giving the lighting of schools very serious attention. But it is not enough for the schoolroom to be well lighted if the children are allowed to read in dimly-lighted corners when they are at home. Again, if children become accustomed to insufficient, make-shift methods of lighting, they in turn, when they grow up, will view the same conditions with indifference in their own homes, and so the evil gets perpetuated.

For the sake of the child, therefore, if for no other reason, good lighting in the home is an urgent necessity.

SOME NOTES ON THE HALF-WATT LAMP.

By An Engineering Correspondent.

At the present moment the sudden withdrawal of supplies of electric lamps from the Continent has drawn attention to the problems involved in their manufacture particularly in regard to the recently introduced half-watt lamp. Some notes on the chief features of these lamps, as outlined in a number of recent papers before various engineering societies, may therefore be of interest.

Life and Efficiency.

Previous to the invention of the half-watt lamp, as we now know it, numerous attempts had been made to improve the efficiency and strength of the ordinary tungsten lamp, one of the most noteworthy steps being the production of drawn wire spiral filaments, which, some people consider, may eventually replace the ordinary straight filaments altogether. It is, of course, well known that an ordinary tungsten lamp could be made to work at half a watt per candle by over-running it, but the disintegration of the filament would be very rapid and the lamp would only last a short time. In a recent paper by Dr. K. Mey before the Verband deutscher Elektrotechniker the following diagram, illustrating the performances of an ordinary tungsten filament run at various efficiencies, was given. It will be seen how rapidly the life falls off when the efficiency is increased beyond one candle per watt. On the other hand the half-watt lamp (shown by the thick curve) was still giving over 80 per cent. of its original candle-power after 800 hours. The writer, however, has received from a trustworthy source a life curve of a half-watt lamp extending over more than 2,000 hours. During the first 200 hours the original candle-power increased somewhat and then fell to its initial value, after which it fell steadily until, after burning 2,000 hours, it was still giving 83 per cent. of the original candle-power.

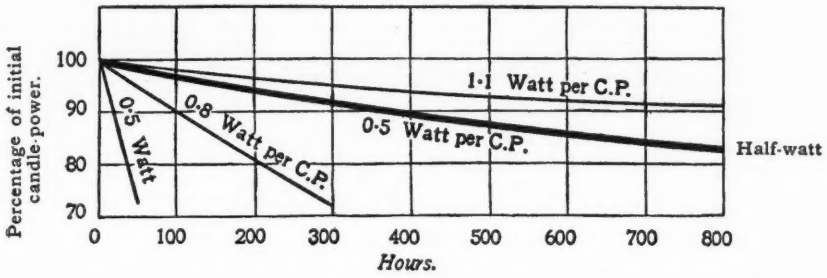


Fig. 1.—Showing diminution in candle-power of ordinary tungsten lamps (*fine line*) at various efficiencies, compared with a half-watt lamp (*thick line*). [Dr. K. Mey.]

Under favourable conditions, therefore, very good results may be expected, although, naturally, if lamps are imperfectly made (as some of the first introduced in England doubtless were) the

life may be considerably less than that shown above.

It is, however, rather too early to give full data on the life of these lamps. From the tests that have come under the author's notice, and also from the published data so far available, it would appear that most "half-watt" lamps operate about 0·65 watts per candle, although with the higher candle-power units more efficient results may doubtless be obtained. But it should be remembered that the increase in efficiency of the half-watt lamp, as compared with the lamp with ordinary straight tungsten filaments, is greater than would appear. The reason for this is that the half-watt lamp approaches closer to a point source, radiating light uniformly in all directions; owing to the long neck and the shape of the filament the obstruction of light by the cap is not so great and the mean spherical candle-power is therefore as much as 85 per cent. of the horizontal.

Theory of the Half-Watt Lamp.

The account of the researches leading up to these results makes interesting reading. They are described in Dr. Mey's paper and also in a recent contribution by Langmuir and Orange.* At 0·5 watt per candle bulbs of ordinary lamps blacken badly in a couple of hours. Means had therefore to be devised of checking this effect. A series of experiments was made on the effect of all the gases likely to exist in lamp bulbs. It was found that the blackening was largely accelerated by the presence of water vapour, and this is believed to be the main cause of the fall in candle-power of badly-made lamps. On the other hand, the blackening of properly-made lamps, as well as those run at exceptional high efficiencies, appeared to be due to simple evaporation from the filament, which occurs at temperatures far below the melting point of tungsten (just as water vapour is given off in large quantities from heated water, long before it boils).

In order to increase the efficiency of tungsten lamps it was therefore necessary either to check the rate of evaporation or to prevent the evaporated material blackening the bulb. Both methods have been employed: (*a*) by the introduction into the bulb of inert gases such as nitrogen, and (*b*) by making use of convection currents so that the evaporated material is carried upwards into the neck of the lamp instead of being deposited opposite the filament.

But it will be observed that the introduction of such gases, which conduct heat, tends to lower the temperature of the filament. To counteract this it is necessary to increase the temperature of the filament still further. Fortunately the amount of light radiated by the filament increases with rising temperature, much more rapidly than the rate of evaporation. By increasing the temperature sufficiently it was found possible to make filaments which would operate in the atmosphere of inert gases at about half a watt per candle for a thousand hours or more. In order to achieve this result the nature of the filament is an important factor. The cooling effect of the gas has a much more serious effect when the incandescent wire is thin than in the case of a stout filament of large diameter. Practically the same result is obtained by winding the filaments in the shape of a tightly coiled helix.

The chief points in the design of the half-watt lamp thus appear to be (1) the surrounding the filament by an atmosphere of suitable inert gases, which checks the evaporation. It is generally believed that nitrogen is mainly used, but Langmuir and Orange state that argon will give better results, and attempts have been made to manufacture this ga: in commercial quantities.

(2) The use of a long neck to the bulb. This serves the double purpose of enabling the filament to be removed as far as possible from the point where the wires are led in, so as to minimise the effect of the great heat; and of providing a chamber into which the heated gases can ascend carrying with them the material thrown off by the filament. (In some lamps a mica screen is inserted

* Paper read before the Am. Inst. of Elec. Engineers, *Elec. World*, Oct. 18th, 1913.

at the base of the neck which would seem to interfere to some extent with this convection effect.)

(3) The use of a thick filament operated at a high temperature and preferably wound in the form of a helix.

Range of Candle-Power Available.

No doubt such a filament is also better fitted to stand such evaporation as exists. Naturally the use of such stout wire filaments makes it somewhat difficult to produce lamps of low wattage for a high P.D. But already it has been found possible to make lamps consuming only 100 watts at 55—65 volts. The half-watt lamp is thus *par excellence* a high candle-power lamp, 1,000—3,000 candles being readily obtained from a single filament, while in the United States a lamp giving as much as 10,000 candles (probably the highest candle-power yet derived from a single lamp) is said to have been made. In this respect the half-watt lamp seems to be going through the same evolution as the ordinary tungsten lamp, and no doubt in course of time lamps of smaller consumption will be made. An interesting new development has been the manufacture of low voltage lamps for automobile lighting giving about 30 candles. The use of transformers in order to enable such lamps to be operated off the ordinary lighting pressure (here again history repeats itself) is well worth consideration.

It is stated in the paper by Langmuir and Orange, that the gaseous contents in the bulb of the half-watt lamp have a pressure, when cold, of about 2/3 atmosphere. When the lamp is lighted up the pressure becomes approximately the same as that of the air outside. This has a rather curious consequence, namely that when the lamp is broken the explosive report that accompanies the smashing of an ordinary tungsten lamp (with the filament operating in vacuo) does not take place. Another point to be noted is that the gases enclosed in the lamp are quite inert and non poisonous and their escape into the atmosphere when the lamp is broken should not have any injurious consequences.

When the ordinary tungsten lamps were first introduced the fragility of the filaments was a drawback. The filament of the half-watt lamp on the other hand appears to be strong mechanically, thanks to the recent introduction of spiralised ductile tungsten wire. The original tungsten lamps were invariably burned in a vertical hanging position owing to the tendency of the heated filament to sag. In the same way (but for a different reason, namely, to facilitate the upward convection effect of the hot currents of air. into the neck of the lamp) it is recommended that half-watt lamps of the ordinary type should be burned hanging vertically.

Proper Methods of Shading Essential.

The high intrinsic brilliancy of the metal filament was often commented upon when they were first introduced. But the brightness of the half-watt tungsten filament (stated by Langmuir and Orange to be 1,200 candles per square inch) is presumably considerably greater owing to its greater temperature of incandescence. The necessity for proper methods of shading is therefore still more evident with the new lamps. This has stimulated the design of special fittings of which there are now a great variety on the market.

Another point that deserves mention is the application of half-watt lamps to indirect and semi-indirect lighting. Indirect lighting was used, but only to a very small extent, with the carbon filament lamps. Then the tungsten high candle-power units arrived and the higher efficiency of these gave a great impetus to indirect and semi-indirect methods. Now, with the half-watt lamps, there is still more inducement to make use of these methods, *firstly*, because the need for screening the very bright filaments is more urgent, *secondly*, because, owing to their higher efficiency, a half-watt semi-indirect system compares very favourably with a direct lighting system using ordinary tungsten lamps. Here we have, again, an illustration of the fact that greater efficiency encourages the use of effective methods of shading.

Opportunities for the Half-Watt Lamp.

Time is needed before it can be seen where the new lamps will be most widely used, and how far they may be expected to replace existing illuminants. But for the lighting of large interiors and for spectacular outside lighting they would appear to have specially good prospects. In many cases one would expect them to prove acceptable for railway station lighting, and in the last issue of this journal a good example was mentioned (Liverpool Street, London). We may also expect to see them widely used for street-lighting, although not much has yet been done in London in this respect. When lamps have to be hung at a high level the advantage of having a unit that does not, like an arc lamp, require periodical attention is evident; possibly, in view of the stoppage of the Continental supply of arc lamp carbons owing to the war, the advantage of this may become still more manifest.

The adaptability of the spiral filament would also seem to favour their use for many special purposes, *e.g.*, in photographic studios, and as cinematograph projector lamps. It is well-known that the great difficulty in applying electric incandescent lamps to projection purposes has been to concentrate the light over the small area required from an optical standpoint. The new compact thick filaments seem to carry us appreciably nearer the solution of the difficulty, and special projector half-watt lamps, with filaments mounted so as to concentrate the light mainly in one direction, have recently been put upon the market.

Photography and "Artificial Daylight."

Another advantage of the new lamps, which will doubtless have a bearing on their utility for photographic purposes, is the whiter colour of the light obtained. According to some recent experiments of Luckiesh the spectrum of the light is not widely different from that of the open white arc.* Colours should therefore appear more "natural" (*i.e.*, as revealed by daylight) than by the light of the old ordinary tungsten lamps.

The fact that the light is already decidedly nearer daylight than that of the ordinary carbon filament also suggests that the lamps could be more easily applied for the production of "artificial daylight." With the ordinary tungsten lamp a close resemblance to daylight can be secured by using a suitable gelatine-glass film, or by coating the lamp with a special lacquer. With the half-watt lamp there should be a double gain. Firstly, because the efficiency is higher and the inevitable loss of light through the use of coloured glasses is not so important. Secondly, because, owing to the whiter colour of the light, it would presumably not be necessary to absorb so much light by the filter or lacquer as in the case of ordinary lamps.

Limits of Efficiency.

Finally, it is of interest to inquire what is the ultimate efficiency likely to be attained with the half-watt lamp. According to a recent series of researches by Lux (one of the most complete physical investigations yet published)* a half-watt lamp taking 0·64 watts per H.K. works at a temperature of about 2,400° abs. Dr. Lux estimates that under present conditions roughly 5 per cent. of the energy given to the lamp is converted into visible light. We are therefore still very far from our ideally efficient illuminant. Further, it would appear that at the melting point of tungsten (approx. 3,200° abs. ?) the specific consumption would be 0·3 watts per H.K., so that physical conditions seem to set a limit to further developments on the present lines. On the other hand it is of course still possible that by altering the nature of the filament and the gases surrounding it still considerable progress may be made. Meantime let us be thankful for the very substantial increase in efficiency already secured.

* The Half-Watt Lamp in Photography, M. Luckiesh, *Elec. World*, July 18th.

* *Elektrotechnische Zeitschrift*, May 28th, 1914.

NATIONAL RELIEF FUND.

[At the present time many readers of "The Illuminating Engineer" are doubtless experiencing the dislocation of trade caused by the war and appreciate only too well the distress that may result. We all hope and believe that the trouble is only temporary and that eventually our industries will be more prosperous than ever. Meantime it is our duty to "hope for the best but prepare for the worst," and especially to see that the relatives of those who have gone to the front do not suffer.

Everyone can help a little and the readiest way of doing so is to subscribe to the National Relief Fund, making use of the coupon reproduced below.—Ed.]

I enclose £ s. d. toward the Prince of Wales's

NATIONAL RELIEF FUND.

Name .....

Address .....

.....

This coupon should be filled in, and the envelope, which need not be stamped, addressed to H.R.H. The Prince of Wales, Buckingham Palace, London.

"THE HOMES THEY LEAVE BEHIND."

We have received from Mr. C. Arthur Pearson, Joint Hon. Secretary of the National Relief Fund, a copy of the song with the above title, written by Mr. Harold Begbie. The music is by Walter Rubens, and the song is published by Messrs. Enoch and Sons (14, Great Marlborough Street, London, E.C.) for the benefit of the National Relief Fund.

The words of the song make a direct appeal for the relatives of those who have gone to the front, the tune is a catchy one, and it is hoped that "The Homes they Leave Behind" will soon be sung far and wide throughout the country.

We note that 75 per cent. of the profits from the sale of the song will be devoted to the National Relief Fund. The remainder will go to the Variety Artistes Benevolent Fund and Institution, this benefiting a class of people who are feeling the effects of the war very keenly at the present time.

"CANADA'S GIFT."

SACKS TO BE SOLD AT 5S. EACH.

Canada is making a splendid gift of flour to the Mother Country. It has been decided that the sacks, when empty, should be sold as souvenirs at 5s. each. Two-thirds of this sum will be devoted to the Prince of Wales's National Relief Fund, and one-third to the Belgian Refugees Fund. The sacks are all marked "Canada's Gift."

Applications for the sacks as souvenirs, accompanied by a remittance of 5s., should be sent to the Hon. Secretaries, National Relief Fund, York House, St. James's Palace, London, S.W. Applications will be dealt with in strict rotation.

REVIEW OF THE TECHNICAL PRESS.

THE number of articles on illumination during the past month has naturally been much less, owing to the stoppage of the Continental journals. A variety of papers were read at the Convention of the Illuminating Engineering Society (U.S.A.) this month but they are not yet to hand.

Most of the journals in Great Britain are occupied with the effect of the war on the lighting industry. Several comment upon the **altered appearance of the streets of London by night,** the running of lamps on reduced pressure and turning out of alternate lamps, and the painting of obscuring bands round the globes so as to make the lights invisible to airships.

In view of the altered conditions now prevailing, an illustrated article in the *Edison Monthly* (June), showing a series of pictures of "The Lights of London," makes rather curious reading. One interesting feature is that in most of these pictures the figures of people and vehicles are shown—which makes one wonder whether they were taken entirely by artificial light!

There are a number of articles of a scientific nature. F. K. RICHTMYER (*Elec. World*, August 22nd) raises the question whether modern eye-strain may not be due in some measure to the fact that we now use our eyes continuously for a much longer period than we used to do; owing to the fact of artificial light being available our eyes are on the *qui vive* almost without cessation, whereas in times gone by the number of hours during which there was no light was much greater. Possibly our eyes may get adapted to the new conditions in course of time.

M. LUCKIESH (*Phys. Rev.*, July) describes some researches on the **flicker photometer,** and the decay of colour sensations. It appears that red and green-blue lights behave quite differently as regards flicker; the persistency of a red flicker on a green ground is not the same as that of a green flicker on a red ground. Also the contour of the boundary between the illuminated surfaces affects the point at which flicker disappears. Nevertheless, the author still considers the flicker photometer one of the best for colour-work, and he describes an interesting experiment designed to test its correctness. Light of a pure spectrum yellow was compared against a yellow identical to the eye, but made up of a mixture of red and green. Now if the component colours do not "add up" satisfactorily, the result with the flicker photometer would not be the same as that obtained by an "equality of brightness" test; yet it was found that the same result was obtained with both types of photometers.

Among other articles we may note J. KOWALSKI (*Bull. Soc. des Electriciens*, May) on the **electric spark as a source of ultra-violet light.** There is reason to think that the electric spark would be a very efficient source of ultra-violet energy, and the author describes tests showing that with his apparatus 10—20 watts would suffice for the sterilisation of one cubic metre of water. He also gives the results of experiments on the effect of the atmosphere in which the spark is developed, the nature of the electrical discharge and the quality of the electrodes, are given.

In the *Electrical World* (July 25th) there is an account of a **new form of searchlight,** the electrodes of which are cooled by a spray of alcohol. This has the effect of keeping the crater within a much smaller area and considerably increasing its intrinsic brilliancy.

A. J. MAKOWER and U. A. OSCHWALD describe some experiments on the starting current of half-watt lamps (*Electrician*, August 28th) which seems to be very

similar to that experienced with lamps of the ordinary variety.

A. L. POWELL describes an installation of these lamps in a church (*Elec. World*, August 22nd), and H. B. WHEELER and J. A. HOEVELER deal with the illumination of small show-windows (*Elec. World*, August 15th).

In the *General Electric Review* for August there is a review of the Report recently issued by the Lamp Committee of the National Electric Light Association. Some curves are presented showing the enormous growth of the incandescent lamp business in the United States and the steady way in which the tungsten lamp has superseded carbon filaments. It is worthy of note that although the average wattage of lamps sold has slightly decreased during the last seven years (from 53 to 47) the average candle-power has been nearly doubled (from 18 to 29·4). This illustrates forcibly the policy pursued in that country of encouraging people to make full use of the new lamps but not to be parsimonious in their lighting. An important element in popularising the new lamps has been the "free renewals" system adopted by many of the leading supply companies.

Among articles on gas lighting we note that by C. B. OUTON on the **Selas system** (*G.W.*, August 22nd, *J.G.L.*, August 18th). This system uses a mixture of two parts air and one part gas, delivered at a pressure of 10 inches. In this installation an efficiency of 50 candles per cub. ft. was obtained. Particulars are also given of the renewal of mantles, which worked out on the average to about two per month with 1,500 c.-p. lamps, and one per month and one in two months respectively with the 1,000 and 500 c.-p. units. We referred last month to the paper by M. LITTLEJOHN on **Street Lighting.** The author considers that mean hemispherical candle-power is the best criterion as to the effective value of a lamp; in theory this is generally admitted to be the case, though in practice it may not be an easy quantity to measure *in situ*.

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"S." British *v.* German Lamps and Fittings (*G.W.*, September 12th).

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The Lights of London (*Edison Monthly*, June).

A Searchlight with Cooled Electrodes (*Elec. World*, July 25th).

CONTRACTIONS USED.

G.W.—*Gas World.*
J.G.L.—*Journal of Gas Lighting.*
Phys. Rev.—*Physical Review.*

CORRESPONDENCE.

WAR AND THE LIGHTING INDUSTRY.

DEAR SIR,

I am in receipt of your letter of the 15th, and I am pleased to say that the war has not adversely affected us, but has in fact brought us many orders which would otherwise have gone abroad. The prospects also seem particularly bright, as we have since the war broke out had inquiries from various parts of the Continent, and even from Warsaw.

We are, of course, continuing as usual, and even more so where German trade is to be captured. There are, however, some difficulties in carrying on, raw materials having gone up all round, and zinc is almost unobtainable. One of the principal works, as perhaps you know, is (or rather was) close to one of the Liège forts. Apart from such troubles we are unaffected, as we have never bought much from Germany, though some kinds of glassware have so far been unobtainable in this country. We hope, however, that the British glassmakers will rise to the occasion.

Yours faithfully,

H. T. WILKINSON

(Managing Director of the Wardle Engineering Company, Limited.)

HALF-WATT LAMPS FOR AUTOMOBILE LIGHTING.

As we go to press we receive from the **British Thomson Houston Co.** (Mazda House, 77, Upper Thames Street, E.C.) particulars of the special half-watt lamps they are manufacturing for automobile headlights.

The type of lamp shown consumes 2 amperes at 12 volts and yields 50 candle-power, and its effect in a headlight must be very striking. Six-volt lamps of half the candle-power are also obtainable. For this kind of work the half-watt filament has some very obvious advantages. Apart from the fact that it gives approximately twice the light for the same energy as the ordinary tungsten lamps (and therefore, light for light, requires only half the battery capacity), the great intrinsic brilliancy of the filament is a great optical gain and the compact spiral filament is excellently adapted for giving a "point source."

It is worth noting that the coming of the drawn wire filament with its great mechanical strength gave the first great impetus to the design of electric lamps for motor-car headlights. Now the half-watt lamp is carrying the process a step further, and it will be very interesting to see what the effect on motor-car lighting will be.

MESSRS. W. SUGG & CO., LTD.

EMPLOYEES AT THE WAR.

We are informed that 46 men in the employment of Messrs. W. Sugg & Co. have joined the colours, representing approximately 10 per cent. of the staff. To those who were called up the Directors have agreed to pay half their weekly wages while at the war, and to reinstate them on their return. All single men joining Kitchener's Army will receive 7s. 6d. per week while the war lasts and will also be reinstated on their return.

The remaining employees are contributing to the National Relief Fund.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

HOLOPHANE GLASSWARE FOR GAS-LIGHTING.

DURING a recent visit to the Holophane Showrooms in Carteret Street (Queen Anne's Gate, S.W.), we were much struck by the complete arrangements for demonstrating the merits of these reflectors with gas mantles. A series of both booths has been arranged in the basement. All the units are equipped with Telephos control, so that they can be switched on and off from a distance. The visitor can judge for himself the improved distribution of illumination secured by adding to the mantle a Holophane reflector instead of the conventional unscientifically constructed obscured glass globes, which are not designed to distribute the light in any particular way, and also absorb a great deal of it.

We understand that the company propose to issue their complete catalogue of Holophane Glassware for Gas shortly, and that the arrangement and printing of this will be distinctly novel.

Holophane glassware is manufactured at Gateshead-on-Tyne and should therefore be unaffected by the war. In this connection it is of interest to quote the following extract from a recent issue of the *Journal of Gaslighting* :—

"There has been among the gas managers of this country a very large patronage of German productions solely on account of cost, with a blind eye to the weight of metal, finish, and performance. . . . Intrinsic value should also count. There is not a single thing in connection with lighting that need come to this country from Germany and Austria, unless it be heat resisting glassware ; and there we have to confess the highest merit does not rest with this country. But it is not all glassware that is exposed to excessively high temperatures. The beautiful prismatic glassware of a well-known company is entirely produced in this country."

HALF-WATT LAMPS MANUFACTURED IN ENGLAND.

A VISIT TO THE B.T.H. WORKS AT RUGBY.

THE sudden stoppage of Continental supplies of half-watt lamps at once raised the interesting question whether British firms would be able to step into the gap and make good the deficiency. The announcement that the British Thomson-Houston Co. were actually making these lamps at Rugby was therefore very welcome.

By the courtesy of the Company we were recently afforded an opportunity of visiting the works at Rugby, and we can state that we have seen half-watt lamps manufactured there. There is a wire-drawing plant at work and apparatus for filling the lamps with inert gases, &c. The factory is already turning out a considerable quantity of Mazda lamps, but we understand that before long the number and variety of lamps available will be greater still, as the demand is growing rapidly.

We may add that the arrangements for the care of the operators are up-to-date, and the ventilation, heating, and lighting are good.

In a subsequent issue we hope to give an illustrated account of some of these interesting processes.

SOME B.T.H. HALF-WATT UNITS.

The coming of the half-watt lamp has led to the introduction of a complete new series of lighting units. The size and shape, and particularly the long neck of the lamps made it essential for the existing forms of shades and reflectors to be re-designed and the concentrated brightness of the filaments has led people to appreciate the necessity for proper methods of shading. A few years ago the introduction of the ordinary metal filament lamp gave a great stimulus to the design of shades and reflectors. Now the half-watt lamps are having a similar effect, especially in many fields of lighting not previously covered by incandescent lamps to any great extent.

Through the courtesy of the **British Thomson Houston Co., Ltd.** (Mazda House, 77, Upper Thames Street, London, E.C.) we are reproducing on the opposite page data relating to some Mazda half-watt fittings. Both these fittings and the Mazda half-watt lamps for which they are intended are British made. In Fig. 1 we have the standard type of weather-proof fitting with opal globe and metal reflector, suitable for outdoor work. The diagram to the right contains the polar curve from a bare 200-watt 110 volt half-watt lamp (shown dotted) and the corresponding curve obtained from the same lamp in the fitting (shown full). It is obvious that the amount of light directed downwards is very materially increased. In Fig. 2 we have similar data for a 500-watt lamp in an Alba lantern, and here, too, the distribution curve is much improved.

The remaining unit (Figs. 3 and 4) is intended specially for street-lighting and is, perhaps, the most interesting of the three. Most people would agree that the design of street-lighting units has not been worked out so scientifically as those intended for indoor use. In many cases the intrinsic brilliancy of the exposed source, seen against a dark background, has a distinctly glaring effect, and it is well known that in most cases the illumination along the street is very far from uniform. It is by no means an easy problem to improve these two conditions, but with the coming of the half-watt lamp we may reasonably expect to deal with the problem more successfully and this new B.T.H. unit seems to be a step in the right direction.

Fig. 4 shows the component parts, Fig. 3 the general appearance of the unit. Surrounding the filament is a cup-like diffusing glass reflector; underneath is another conical white reflecting surface, having at its top a ventilating aperture. The filament is thus completely screened from view except over a small angle slightly below the horizontal (where, as is well known, the maximum candle-power for street-lighting purposes is required). The peculiar polar curve of light distribution obtained from the unit seems to be well adapted to securing uniform street illumination. A comparison of this curve with that of the bare lamp shows very clearly how greatly the natural distribution of light from a source can be altered by the use of appropriate reflectors.

FIG. 4.—Component parts of new Mazda street-lighting reflector shown in Fig. 3.

The appearance of a row of these new units would be most striking and it would be interesting to see a street lighted in this way. We hope before very long to have an opportunity of doing so. Meantime we propose in another issue to describe a few more half-watt fittings, including those of the semi-indirect type which find great favour for use with half-watt lamps.

(*To be continued.*)

FIG. 1.—Mazda "Half-watt" lamp in weather-proof reflector.

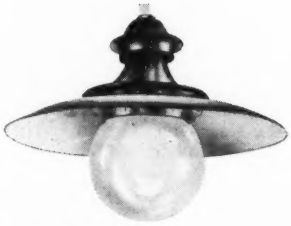


FIG. 2.—Mazda "Half-watt" lamp in Alba lantern with over-reflector.

FIG. 3.—General view of new Mazda patent street-lighting unit (with street-lighting equipment patent No. 21485/12).

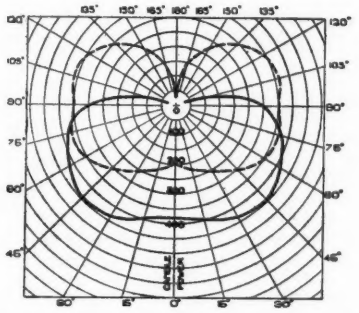


FIG. 1A.—Polar curve of 200-watt 110-volt lamp (*dotted line*) and corresponding curve of lamp in lantern with opal globe (*full line*).

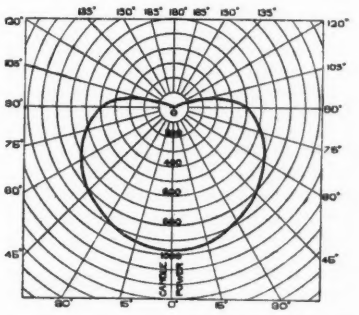


FIG. 2A.—Polar curve of 500-watt 110-volt lamp with fitting shown in Fig. 2.

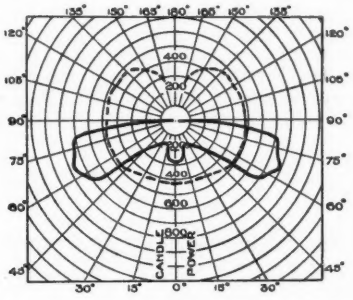


FIG. 3A.—Polar curve of 300-watt lamp (*dotted line*) and corresponding curve (*full line*) in new street-lighting equipment shown in Fig. 3.

MAZDA HALF-WATT LAMPS AND FITTINGS.

THE MANUFACTURE OF TUNGSTEN LAMPS.

A Visit to the "Osram" Lamp Works of the General Electric Co.

On Wednesday, September 23rd, a number of representatives of the press visited the Osram Works at the invitation of the General Electric Co. In view of the stoppage of foreign supplies of lamps owing to the war, many of those present were curious to hear and see what special measures were being taken by leading manufacturers in England. The Osram works have taken prompt and enterprising steps to meet the exceptional demands, and it was stated that they are now in a position to manufacture lamps quite independent of foreign materials. The glass bulbs are made at the company's factory at Lemington-on-Tyne, and the caps, which until recently were imported from abroad, are also being made in England.

Visitors were afforded an opportunity of seeing the deft operations of girls at work preparing the filament supports, winding the drawn wire upon them, and subsequently mounting the cage in the bulb preparatory to exhausting; also of admiring the highly ingenious, specially designed machinery by which the various parts are manufactured. What, however, most interested visitors was the operation of drawing out tungsten into wires of incredible thinness. They were also shown how the grey tungsten powder is converted under hydraulic pressure into rectangular bars and fused into a solid state by an electric current, the ductile tungsten being then gradually drawn out into wire in successive stages. Another interesting operation was the winding of spiralised filaments suitable for lamps with small bulbs and for the manufacture of half-watt lamps. It is hoped that very shortly this department will be in full swing, the urgency of the demand for ordinary tungsten lamps and the enlisting of a large percentage of the staff having somewhat delayed operations.

As regards the ordinary tungsten lamps it is stated that the works are now capable of dealing with an output of about ten million lamps per annum; the additions to the factory made last spring seem to have been in the nick of time.

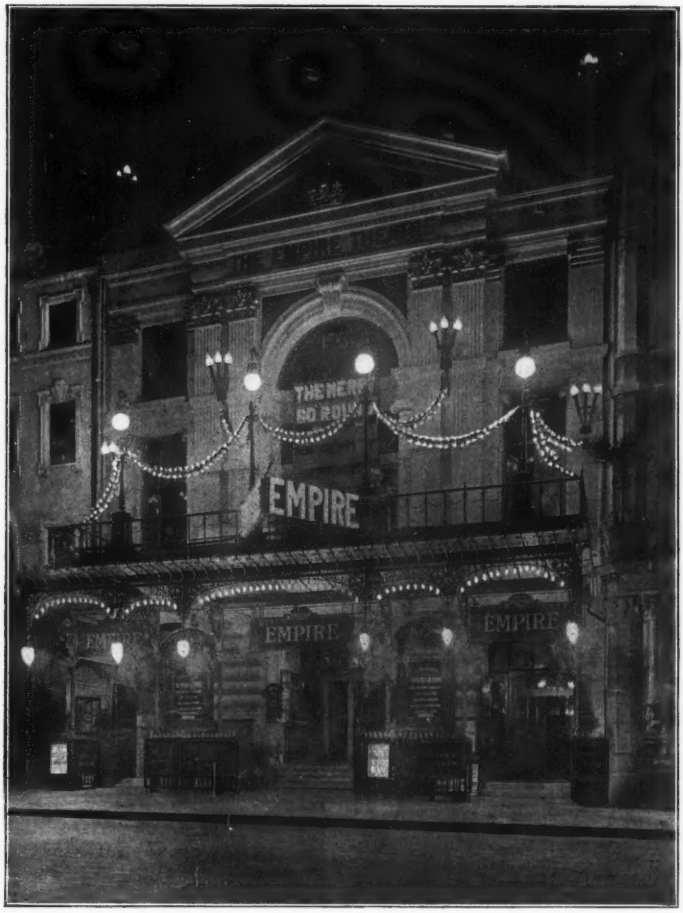
Visitors were also impressed by the pleasant and hygienic conditions under which the employees carried on their work and by the arrangements made for their comfort. Not the least spectacular event of the day was the fire-alarm which emptied the factory in a few minutes, and enabled the Osram Brigade to demonstrate its efficiency. Subsequently the visitors were the guests of the company at luncheon at the Clarendon Hotel, Mr. Byng presiding. The Mayor of Hammersmith gave some illustrations of the benefit to the district of so large a works in their midst, and Mr. C. Wilson explained that the Osram Works were essentially a British concern developing in this country what, it must be owned, is a foreign invention. May we hope that in the future a still further step will be taken—that we shall see lamps not only of British manufacture but "British-invented" as well!

Mr. S. Rentell and Mr. Fielden expressed the thanks of the guests, many of whom paid a further visit to the factory during the afternoon. Certainly a timely and most interesting visit!

THE EDISON AND SWAN UNITED ELECTRIC LIGHT CO., LTD.

As mentioned in our last number we understand that this company is in an excellent position to do its share in taking up the demand for incandescent lamps caused by the Continental shortage, and we hope soon to take advantage of an invitation to visit the works at Ponders End. It is satisfactory to learn that a firm so closely associated with the inventions of the late Sir Joseph Swan is well equipped to utilise the unique opportunity afforded by the present situation, and it is scarcely necessary to add that the Edison and Swan United Electric Light Co. is essentially an "*All-British*" concern.

HALF-WATT LAMPS OUTSIDE THE EMPIRE THEATRE.



Lumina Bureau Photo.

In the above illustration we reproduce a view of the Empire in Leicester Square, taken entirely by artificial light. The taking of this photograph was by no means an easy matter, owing to the large crowds of people assembling outside this building until quite late at night.

There is an interesting variety of illuminants used. On the roof of the building will be noticed some "torches" using ordinary tungsten lamps, lower down will be seen signs and festoons of miniature glow lamps and also a series of four silica mercury vapour lamps.

Under the balcony are a series of 200-volt, 500-watt (1000 candles) half-watt lamps, installed by the **General Electric Co., Ltd.,** and giving a very brilliant illumination over the steps leading into the theatre.

SEMI-INDIRECT GAS LIGHTING IN A BALL ROOM.

View of the Ball Room at the Roebuck Hotel, Buckhurst Hill.

THE above illustration, for the use of which we are indebted to the **Gas Light and Coke Co.**, illustrates the lighting of a room at the Roebuck Hotel, Buckhurst Hill, frequently used for dancing, and artistically lighted with semi-indirect gas fittings.

The semi-indirect system of lighting has lately come into very general use for electric lighting, but there is no reason why it should not be used equally well with gas and quite a variety of gas units of this kind is now available.

The advantages of the system are that the light is softened and diffused, and the mantles being screened completely from the eyes, good use being made of the reflecting powers of the ceiling. In this way the light is spread into all corners of the room, but, owing to the reflectors being translucent, a certain proportion of the light is also transmitted downwards. Another point to be noted is that, with the light thus spread all over the room, the furniture can be displaced without the illumination being prejudicially affected as would be the case if local lights were used for each table. In this case, for example, the floor can be cleared and the tables replaced again without the least trouble.

The lighting of ball rooms is conveniently controlled by a tap on the floor level so that the gas can be quickly turned down at times when not required.

We shall be glad to hear from any of our readers who can also send us particulars of other interesting semi-indirect gas lighting installations of this kind.

INDEX, October, 1914.

		PAGE
Correspondence		494
Editorial	L. GASTER	469
Home, Lighting of the		483
Illuminating Engineering Society (U.S.A.) Eighth Annual Convention		477
Illuminating Engineering, Short Notes on		479
London, Lighting of		476
National Relief Fund		491
Panama Exhibition, Lighting at the		473
Review of the Technical Press		492
Topical and Industrial Section		495

(Holophane Glassware for Gas—B.T.H. Half-Watt Lamps and Fittings—Half-Watt Lamps for Motor-car Lighting—A Visit to the Osram Works—Half-Watt Lamps outside the Empire Theatre—Semi-indirect Gas Lighting in a Ball Room—Blanchard Lamps at the South Pole)

NOTICE.

Owing to the demand for Back Numbers the cost of Vols. I.—VI. will in future, and until further notice, be **12s. 6d. unbound** and **15s. bound** to **Non-subscribers.**

Yearly Subscribers and **Members of the Illuminating Engineering Society,** however, can obtain these volumes at a cost of **10s. 6d. unbound** and **12s. 6d. bound.**

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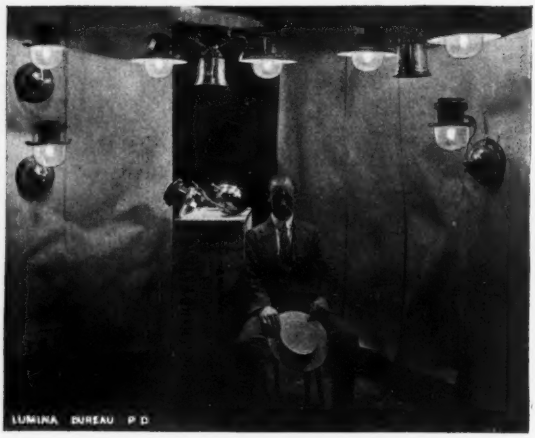
BLANCHARD LAMPS AT THE SOUTH POLE.



Lumina Bureau Photo.

A SHORT time ago we mentioned that Sir Ernest Shackleton's expedition to the south polar regions was carrying with it a number of Blanchard incandescent oil lamps for use on board ship and in camp during the dark winter months when the sun never rises above the horizon. The comfort of having powerful self-contained lamps capable of yielding several 100 to 1,500 candle-power in such circumstances can be imagined. It will be recalled that these lamps employ paraffin vapour, and we understand that they work quite satisfactorily even at the very low temperatures met with in arctic regions—a remarkable testimony to their adaptability to all climates and conditions.

The illustration is reproduced from a photograph of Mr. Wild, Sir Ernest Shackleton's intrepid second in command, taken at the offices of the **Blanchard Lamps, Limited,** Farringdon Road, London, E.C., shortly before the departure of the expedition. It will be noted that the photo is taken entirely by the light of the lamps themselves, no flashlight or other extraneous aid being employed.

BUSINESS TRANSACTIONS IN WAR TIME.

MANY people must have been puzzled by the curious business positions that have arisen during the past month owing to the war. There are many technical questions with regard to payments to foreigners, contracts in war time, liability for war risks, contraband of war, &c., which few business men have encountered before.

A special circular on the subject has been issued by the London Chamber of Commerce. A series of sixteen queries is published and precise answers to these are given. In addition there are quotations from legislation bearing on this matter.

We think this circular, dated August 15th, should be of interest to many of our readers.

11

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LEON · GASTER

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EDITORIAL.

BRITISH IDEALS IN PEACE AND WAR.

In the last issue we expressed the hope that a statement of the British case in regard to the war would be made by a representative committee of scientists and men of learning. We are glad to see that such a statement has now been issued.* Full recognition is given to the undoubted achievements of German men of science; sorrow is expressed that those whose names are known and honoured for such services should endorse a policy of aggression which seems to us so grievously wrong. It is stated in the clearest manner that England fought for peace up to the last minute and only entered the lists when there was no alternative. "British honour, British interests and British obligations" compelled us to take the step.

The time should surely be past when nations can be guided solely by

> "The good old rule, the simple plan
> That they should take who have the power
> And they should keep who can."

We do not believe that this country would ever acquiesce in the maxim that "might is right," that it could adopt militarism as its guiding aim

* *Westminster Gazette*, Oct. 21st, 1914.

and use the armies it is creating for unworthy objects. It may be true that in times past the nucleus of the British Empire was largely obtained through war. But its continuance and solidarity, and the acquiescence of the world in its existence, would have been impossible but for the broad spirit of freedom, toleration, and goodwill by which it is held together. Of this wise policy we are reaping the reward at the present moment, when we see the enthusiasm with which our Colonies and Dominions are standing by our side.

Again, England's credit throughout the world has been justified by her treatment of the refugees from many lands who have sought her protection. Their presence has been a strength to us and not a weakness. It is common knowledge that the naturalised foreigner quickly becomes more patriotic than the subject born and bred ; and naturally so, because *he* is a subject by choice and not by the accident of birth.

But since the war began the seeds of suspicion have been sown and are now bearing fruit. It is surely unreasonable to hold a naturalised subject responsible for the actions of a country which he has voluntarily abandoned. To many of foreign descent it has come as a revelation to find that in certain sections of the Press and the public twenty or thirty years of honourable residence, and even naturalisation, are no longer regarded as evidence of identification with the aims and ideals of this country. Thoughtful and well-informed persons, we feel sure, do not take this view. But we must remember that the bulk of the nation is made up of people whose information is necessarily superficial, guided by emotion rather than by reason ; it is therefore essential, that any measures taken for the safety of the country should also be guided by a spirit of fair play.

We may surely trust the authorities in this country to maintain British traditions for tolerant and well-considered action, even in times like these when the strain is so severe. We quite agree that in any case in which there is proof, or even good ground for suspicion, they should take prompt and strong measures for the safety of the public. The whole nation, needless to say, would support them in such a course. But it should surely be made clear that naturalisation papers are not to be treated as " scraps of paper," of no protection to those who hold them.

Moreover, it is already being pointed out that unduly severe action may occasion reprisals of a kind undreamed of in this country. For the sake of our unfortunate subjects in the enemy's country, therefore, we should act with special care in this matter and not yield too hastily to the clamour of uneducated people for extreme measures.

Finally, it must be realised that any unjustified action in this matter will immediately be taken up by the enemy and used to our discredit, and that unkind treatment of innocent people would leave traces that years of peace might not efface. We are, however, quite sure that the country means to be fair to those who have sought its protection and the authorities will see to it that British ideals will not suffer, even in times of strain and anxiety such as these.

BUSINESS RELATIONS IN WAR TIME.

The considerations urged above also apply to business relations. It is natural and proper that in war time trading with enemies should cease, and the Home Office have taken steps to ensure that no such business can be transacted. It is equally natural that everyone should wish to encourage firms in this country who are making strenuous efforts to grapple with a difficult situation, and to take every advantage of the position to start manufactures which have hitherto been carried out abroad.

The question of businesses which are largely conducted by foreign capital requires careful consideration. Here again we should take a commonsense and businesslike view. There is no reason to object to businesses being built up with foreign capital; Great Britain itself is one of the greatest investing nations and its capital has financed many enterprises in the countries with which we are now at war. Therefore any attempt to dispossess foreign owners of businesses here would merely be the signal for reprisals abroad—by which we might lose materially as well as morally. Moreover, it is obvious that a business which, although using foreign capital, employs thousands of British workmen and provides work for many subsidiary purely British enterprises, is, on the whole, doing good rather than harm; and the cessation of its activities would bring ruin to many. We may also reasonably assume that a time will come when commercial relations will be reopened with those who are now our enemies; and the less cause for bitterness on both sides the easier it will be to re-establish relations. The mere fact that we are fighting for such high ideals should make us particularly careful to avoid tactics of spoliation, which would undoubtedly bring us into discredit and be remembered against us in time to come. We have always prided ourselves on the fact that the British merchant's word is his bond; commercial agreements, therefore, cannot be repudiated at a moment's notice even in war time. They should merely fall into abeyance for the time being. The only thing we must ensure is that while the war is on, *no money is transmitted to Germany*, and we may be confident that the Government will see that this proviso is carried out.

The other great question that is being debated just now is the use of foreign patents held in this country. We are bound to say that even here we cannot agree with those who argue that all patents held by enemies should be swept away. To our mind this would be equivalent to repudiating our engagements and treating them in the "scrap of paper" spirit, which has formed such a disagreeable feature of German diplomacy. Here again we must remember that any action of the kind could be reciprocated in Germany, and it is possible that we might suffer considerably by such retaliation.

On the other hand, some German patents controlling the manufacture of essential things may surely be temporarily set aside while their owners are unable to make use of them; but the course to be followed after the war

is a matter for mutual agreement between the nations. Meantime, even in these cases it is not proposed to rob the inventor; the money due in the form of royalties is to be set aside, *but not paid* until the war is over.

Existing patents, however, are not everything. We hope that one result of the above policy may be to stimulate invention in this country. If new and better processes, controlled by entirely new patents, could be secured it would make our position still more unassailable and enable us to hold what we have gained when the war is over. We have been too accustomed to leave the initial experimenting in foreign hands. Now we have got to shift for ourselves, and although the process is slow at present, it may be for our good in the long run.

THE EIGHTH ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

In times like these it is a relief to turn our eyes towards parts of the world which are as yet free from the anxieties and distractions of war. We are glad to see that the Eighth Convention of the Illuminating Engineering Society in the United States has proved as successful as usual. The number of communications presented (27 papers and two reports) was large, and the attendance is stated to have been exceptionally high.

In the present issue we are reproducing a portion of the "Summary of Progress" during the past year, which is evidently intended to be an annual feature. It is clear that a great deal of work has been expended on this Report, and the references alone make it a most useful production. We are glad to see frequent quotations from the transactions of the Illuminating Engineering Society in London; we may instance particularly the summary of the work carried out by the Committee on School Lighting, which is also referred to in a paper by Mr. L. B. Marks on Daylight Problems. The development of the principle that the two Societies should keep closely in touch with their mutual activities should be still further extended, so that work carried out in one country need not be repeated, but commented upon and carried forward in the other.

We must postpone discussion of the many interesting papers submitted at the Convention to another issue. In the meantime we note that the social part of the programme was thoroughly enjoyed, and there is no doubt that Cleveland, where the Nela Works of the General Electric Co. are situated, was a most suitable place for the gathering. The writer has a vivid recollection of the hospitality of the Nela Works which he visited in 1912, and can speak from personal experience of the courtesy and good feeling which prevails among the whole staff. We have received from some friends in that city a series of delightful photographs showing the chief features of interest at Nela Park, and we mean to utilise some of these in connection with our account of the Convention.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(A Report presented by the Committee on Progress at the Eighth Annual Convention of the Illuminating Engineering Society (U.S.A.), at Cleveland, Sept. 21–24, 1914; slightly abbreviated.)

IT will be recalled that the Committee presented their first Annual Report of Progress at the corresponding Convention at Pittsburgh last year, and it was subsequently reproduced in this journal. We again propose this year to present to our readers this valuable record of annual progress in illuminating engineering.

The Report is divided into sections dealing with the following subjects:—

Gas Lamps and Appurtenances; Electric Incandescent Lamps; Arc Lamps; Vapor and Vacuum Tube Lamps; Lights for Projection Purposes; Miner's Lamps; Street Lighting; Exterior Illumination; Interior Illumination; Photometry; Illuminating Engineering Societies; International Illumination Commission; Globes, Reflectors and Fixtures; Physiology; Legislation; Literature.

Gas Lamps and Appurtenances.

Burners.—What is claimed to be one of the most important developments since the introduction of the incandescent gas mantle, lies in a new type of burner.[1] Application is made of a recently discovered principle of gas lamp design, and the result is a lamp in which the operating costs are practically cut in two. The necessity for the use of cylinders is avoided. The new burner works on a novel principle in that the kinetic energy of the gas is fully utilized to secure uniformity of mixture, which is accomplished by providing scientifically designed stream lines for the gases.

For residential work very small mantles are used, giving approximately 30 candlepower each, which are considerably stronger than the older types. These

[1] *Amer. Gas Lt. Jour.*, April 3, 1914, p. 77.

small mantles are used in clusters of three, so that in case of accident to one, illumination is not completely shut off.

Another innovation in burners utilizes experimental data[2] indicating that in the bunsen burner of either the upright mecker type or the ordinary inverted form, the highest temperature is immediately above the points of the small green inner cones. This discovery has led to the construction of an inverted mantle burner in which the mouth of the tube is covered with a fine wire net which forms the desired green cones. The mantle lies immediately below these cones. The permanent gas consumption of the lamp is given as 0·69 litre per candle-power, a factor which approaches results obtained with high pressure gas.

Use of the regenerative principle is made in a new burner[3] for either high or low pressure gas. The secondary air is passed through a heating chamber, heated directly by the products of combustion, and is delivered to the lower surface of the mantle. Effiiciences as high as 50 candles per cu. ft. (0·28 cu. m.) of gas (mean lower rating) have been obtained with burners using this principle.

The high pressure lamp using fused silica for the globe or cup has been still further developed.[4] The increased temperature of the burner nozzle owing to the proximity of the cup and consequent concentration of heat, required a search for suitable material which has recently been found. The tendency to explode the contents of heater and mixing tube on turning off the gas has been remedied by enriching the mixture beyond the explosive range at the moment of extinction. Improvements have been made also in the design of the lamp as a whole both from the utilitarian and æsthetic standpoints.

A new method which claims to increase the life and light giving power of gas mantles[5] consists in dipping the new mantle into a solution of kaolin and permanganate of potash. It is then thoroughly dried at a moderate temperature and may be burned off and used immediately or laid away. In order to preserve the mantle it is recommended that the immersion be repeated, two immersions sufficing to increase the life and usefulness much beyond the average.

An elaborate investigation has been carried out on the influence of the form of the mixing tube, on the injector action, and heating effect on the tube, in a mantle burner.[6] One of the results reached is that for the ordinary low pressure burner which takes in the primary air of its immediate surroundings without suction, the best operating conditions are obtained if the air openings taken collectively are kept at least three times the area of the cross section of the lower mixing tube opening.

A complete explanation has been worked out for the fact that a conical enlargement of the mixing tube remedies the objectionable heating (objectionable from the standpoint of thermo-dynamics) in the case of those burners whose air-gas mixture becomes heated on its way to the mouth of the burner. Furthermore it has been shown that a mixing tube made up of a series of cylindrical pieces of progressively increasing diameter is completely equivalent to a conically diverging tube.

Automatic Lighters.—The question of the automatic gas lighter continues to interest the inventor and during the year a number of new devices have been described. Among these may be mentioned a pyrophoric distance gas lighter[7] which causes a cerium-iron block to be rasped by a file in the form of circle controlled, through a toothed wheel and rack, by a solenoid. The current through the solenoid is governed by a button or other suitable device. An electric type has a by-pass and a heated platinum wire. Another pyrophoric device is arranged on the chain-pull system.[8]

Abroad automatic ignition has found considerable favour, but until recently it has not gained much headway in this country.[9] However two systems are being introduced which look promising

[2] *Jour. f. Gas.*, March 7, 1914, p. 217.
[3] *Amer. Gas Lt. Jour.*, May 4, 1914, p. 286.
[4] *Jour Gas Lt.*, April 28, 1914, p. 233.
[5] *Jour. Gas Lt.*, March 17, 1914, p. 723.
[6] *Jour. f. Gas.*, November, 1914, pp. 1069, 1097, 1125.
[7] *Elek. Anz.*, January 15, 1914, p. 67.
[8] *Jour. Gas Lt.*, February 3, 1914, p. 295.
[9] *Proc. Amer. Gas Inst.*, November 8, 1913, p. 349.

and have already met with some success. One uses a valve operated by a change in pressure in the line leading to the lamp while in the other a small auxiliary gas line is used to operate the valve.

A foreign system of electric ignition has been developed in which electricity at low pressure is carried from the point of control to the fixture, where by means of a miniature induction coil it is stepped up to the sparking point. An improvement on this device, worked out in this country, utilizes the low voltage supply to operate the valve and the high voltage to produce the spark, the whole apparatus being confined to a single small receptacle which can be placed in the canopy of the fixture.

Tubing.—A most important auxiliary[10] of the portable gas lamp is the connecting tubing, generally of rubber. As the result of experiments with lime, glycerine, and powders, a new tube has been developed which is claimed to be quite impermeable to gases and will last several years without serious depreciation. The heat resistance is good, its pressure resisting capacity greater than that of rubber and its cost is low.

Carbureted air.—Where coal is dear and petroleum or gasoline is abundant,[11] the use of carbureted air for village lighting has seemed highly desirable owing to the inexpensive character of the plant required. But technical difficulties have hitherto stood in the way of the general adoption of this system. A new procedure[12] eliminates many of the former difficulties by carbureting air in the immediate proximity of the burner where it is to be used instead of doing so at the works. The main distribution system then becomes one of compressed air, while the carburetors are located at stations situated at different parts of the area of supply.

It is claimed that Balcombe, a Sussex village, is the first English village to have its own petrol air gas supply, the latter having been recently installed.[13]

Acetylene.—An Italian society, The Société Générale, has offered a prize of 500 lira for the best type of acetylene lamp for use on bicycles.[14]

Two years ago there were 106 government acetylene navigation lights in use exclusive of buoys.[15] The last report shows an increase of 246 and a proposed further increase of 43.

The developments in the use of acetylene in mines will be mentioned under another heading.

Kerosene Incandescent Lamp.—A successful wick feed kerosene incandescent lamp has been perfected and is being introduced for rural lighting in this country.

Electric Incandescent Lamps.

Non-Vacuum High Efficiency Tungsten Lamps.—Last year's report contains a brief statement heralding the advent of the high efficiency tungsten lamp, and its introduction in a wide variety of sizes constitutes the most marked development in the sphere of the electric incandescent light. The use of the spirally wound filament in an atmosphere of neutral gas has made possible a higher temperature and a consequent considerable increase in light intensity, while at the same time bringing the source itself into such a relatively small space as to enhance its value when used in searchlights, in projection lanterns or with focusing reflectors.

At the time of the 1914 report of the Lamp Committee of the National Electric Light Association[16] these lamps were available in the following sizes: for multiple burning on 100–130-volt-circuits 400, 500, 750 and 1,000 watts or in candle-power 535, 715, 1,250, 1,820; for series burning the number of units was larger ranging by moderate steps from 60 to 1,000 candle-power with a voltage range from approximately 6 to 55 and in ampères of 5·5, 6·6, 7·5 and 20. In England for the 100—130-volt range, lamps were announced of 400, 600, 1,000, 1,500, 2,000 and 3,000 mean hemispherical candle-power.[17] At the same time announce-

[10] *Jour. Gas Lt.*, March 3, 1914, p. 565.
[11] *Light Jour. & Eng.*, (London), May, 1914, p. 243.
[12] *Jour. Gas Lt.*, April 21, 1914, p. 188.
[13] *Light Jour. & Eng.*, (London), June, 1914, p. 248.
[14] *Sci. et Art le l'Eclair*, January, 1914, p. 1.
[15] *Acet. Jour.*, March 1914, p. 346.
[16] Report of Lamp Committee, National Electric Light Assn., June, 1914.
[17] *Elec. Eng.*, (London), February 19, 1914, p. 108.

ment was made of series burning 50—56-volt lamps in 200, 400, 600 and 1,000 candle-power sizes, and of multiple burning on 200—260-volt circuits in 1,000, 1,500, 2,000 and 3,000 candle-power sizes. Subsequently this listing has been extended considerably.[18] In this connection it should be noted that the changes in schedules of these new lamps have followed each other with such rapidity that before this report is published there will doubtless be available new limits of voltage and efficiency and new ranges of candle-power and watts.

In Germany the 50-volt, 110-volt and 220-volt types were advertised late in the fall.[19] These lamps were tipless and contained nitrogen at an absolute pressure of about nine pounds per square inch (0·53 kg. per sq. cm.).

The new high efficiency lamp is being used in German theatres,[20] and in this country in many places requiring very intense sources, such as display lighting and for the lighting of large areas. It is already a strong competitor of the ordinary arc lamps and the high power gas arcs. Efforts are being made[21] to develop this lamp for use in moving picture machines where steadiness and high intensity are important.

Investigations of the properties of this new lamp have indicated[22] a reduction factor in the neighbourhood of 0·850, a temperature of approximately 2,600° C. and a ratio of radiated energy to energy input of 60 per cent. as compared to 88 per cent. for the ordinary vacuum type tungsten lamp. A study of the energy distribution showed the wave length of maximum energy to lie close to 1·1 μ ($\mu = 0{\cdot}001$ mm.) and the ratio of luminous to total energy radiated to be approximately 8 per cent. as compared to 4 per cent. for the ordinary vacuum lamp. The ratio of energy radiated in the visible part of the spectrum to the energy input was found to be approximately 5 per cent. as compared with 3·5 per cent.

(To be continued.)

[18] *Elec. Eng.*, (London), July 23, 1914, p. 422.
[19] *Elek. Anz.*, October 9, 1914, p. 1144.
[20] *Zeit. f. Bel.*, June 10, 1914, p. 200.
[21] *Elec. World*, March 28, 1914, p. 713.
[22] *Zeit. f. Bel.*, January 20, 1914, p. 14; *Zeit. f. Bel.*, March 10, 1914, p. 75; *l'Electricien*, June 6, 1914, p. 353.

THE BRITISH EMPIRE AND OUR WORK IN IT.

THE above was the title of the Presidential Address delivered to the Association of Engineers in Charge by Mr. Frank Bailey last month.

In the course of his address Mr. Bailey naturally dealt with industrial conditions in this country, and attempted to analyse the conditions limiting our expansion in the manufacturing world. We have, he said, "a Government fully alive to domestic needs; a national laboratory under distinguished scientists; polytechnics and technical schools which rival the best in other countries; good supplies of raw material and the cheapest supplies of electrical power of any country in the world; and, finally, an army of workers skilled in handicrafts, strong in physique, and always willing to earn or receive more money.

"What, then, is the reason of our apparent failure to expand or take a larger share in these trades?" Mr. Bailey suggests that finance, tariffs and adaptability all contribute in some measure to the result. Industrial banks, which play a great part in developing industry abroad, are lacking in this country.

"But the weakest link in our chain of progress appears to be the method of ascertaining the right way to go to work; sometimes it is achieved by actual experience or, in other words, by trial and error, but rarely by systematic investigation."

It is the appreciation of the benefit of scientific methods, and plodding perseverence in applying them that mainly explains the great industrial advances on the Continent.

PHOTO-SCULPTURE—A NOVEL USE FOR PROJECTED LIGHT.

In a paper before the recent Convention of the Illuminating Engineering Society in the United States, Mr. J. Hammond Smith suggested a novel method of automatically reproducing the shape of solid objects. Hitherto, by the aid of photography, we have been able to reproduce views of surroundings in one plane; by means of colour photography we have even been able to reproduce their natural tints. But so far there has been no method of reproducing solid objects in three dimensions.

Mr. Hammond Smith suggests an optical method of doing this. Suppose that a statue is illuminated and photographed from two distinct directions. Then if these two images are afterwards projected in the directions from which they were taken, the two images will coincide somewhere in space and we could trace out the shape of the solid object by moving a white surface to and fro in order to find the points where they do so. Naturally, in order to completely determine the shape of a statue it would be necessary to have photographs from several points of view.

However, the difficulty in this process would be that most objects do not have sufficiently prominent points on their surface for the point of coincidence to be determined with precision. Accordingly Mr. Hammond hit upon the device of projecting from a second apparatus a series of fine letters and lines on the object to be reproduced. We thus get a series of "artificial" prominent points which of course appear in the photographs. In practice, therefore, solid objects are covered with a network of projected lines in this way, and photographed from several directions. Then these photographs are projected in space from exactly the positions in which they were taken. The material from which the sculptor is to work is mounted where the beams coalesce, and material is either carved away or added until the images coincide. In this way the exact form of the solid object is gradually traced out.

FIG. 1.—Photograph of a bust with record photo. projected upon it in approximate coincidence.

No doubt the process as at present executed is a crude one, but it is distinctly interesting and might have important developments in course of time. Fig. 1 shows a photograph of a bust with the record photograph projected thereon in approximate coincidence.

It is also stated that remarkable effects can be produced by images of coloured lantern slides projected from several directions on to a statue, so as to exactly fit upon it. It appears that the combination of the likenesses has a startlingly life-like effect.

"LIGHTS OUT."

Some comments in the Press on the lighting conditions in London during the past month.

IN the following pages we have collected together some of the most interesting comments in the Press on the peculiar lighting conditions in London at the present moment. It will be seen that many different views are expressed, but it is very generally agreed that the gloomy conditions have a distinctly oppressive effect on the public mind.

One effect the situation has certainly had—it has shown many people how dependent we are on proper street lighting, so that its importance should be better appreciated when at last the time comes to revert to normal conditions.

WAR PRECAUTIONS AND LESSONS.

The new order issued yesterday for further restriction of the lighting of London shops and London streets is a very useful precaution against a risk which is not altogether to be despised. That a Zeppelin attack upon London would in the least degree affect the general course of the war nobody even in Germany believes; but it might do an appreciable amount of damage to public and private buildings and it might cause the loss of life or limb to a few non-combatants, of whom a considerable proportion would be women and children. That is the end of the mischief that a Zeppelin raid would do, and if the Germans think this end worth attaining doubtless they will try to compass it, regardless of the rules of the Hague Convention. It is therefore just as well that we should all take the precaution of keeping our lights low. Incidentally that precaution may teach us a little wise economy. To have the streets always as dark as they are now would be most disagreeable; but at the same time it is clear, if note be taken of the number of lights now extinguished, that the previous standard was unnecessarily extravagant. Half that standard would still give us streets more brilliantly illuminated than was the custom anywhere even a dozen years ago. A similar consideration applies in many other directions. The tremendous growth in the wealth of the nation during the past generation has led to both public and private extravagance. Much of this extravagance gives no real pleasure to anybody; it is the result of carelessness and of ostentation. If the war should teach us—as already it is doing—that life can be happy—perhaps, indeed, happier—on a simpler scale of living, we can write that down as a big offset against war sorrows and war losses.—*Daily Graphic*, Oct. 7th, 1914.

DIMINISHED LIGHT AND FAST TRAFFIC.

Mr. Oddie, the Westminster Coroner, in holding an inquest on two persons killed in the streets, said that he had had three such fatalities reported to him the previous day, all occurring after dark. The reduction of the lights in the streets of London is a military necessity, for which in any case we should have to pay a fairly heavy price, but unless there is unusual precaution that price will be quite unnecessarily heavy. Since the beginning of the war all idea of the speed limit for motors seems to have gone. When cars bearing the magic letters "O.H.M.S." appeared obviously no restrictions on these were desirable. But the blind eye turned by the police on the official car led all drivers to assume that regulations would no longer be enforced, and our main roads have become racing-tracks for motor cars.

Obviously, that condition cannot be allowed to continue if we are to have London's streets almost as dark as country lanes. There will have to be strict regulation, and the use of powerful searchlights on cars must be stopped so far as the centre of the Metropolis is concerned. Otherwise the whole purpose of the official ordinance will be defeated. The searchlight is a great danger to other traffic. Now, too, that all omnibuses and tramcars crossing the bridges do so with lights extinguished, it is important that speed should be reduced to little more than a walking pace. Unless we look after these points the casualties in the streets will exact a heavier toll from us

than would a very large number of airships dropping bombs as they have done in the case of Paris.—*Westminster Gazette*, Oct. 12th, 1914.

Dark Streets and Increased Accidents.

In some quarters we find there is a disposition among the electric lighting companies to urge that the restrictions now placed upon the lighting of thoroughfares and shop windows is leading to an increase in the volume of crime and accidents. As regards the latter point the statement appears to admit of no doubt, as many claims have been received by the insurance companies for personal damage sustained after dark as a result of the gloom in which the Metropolis is now habitually involved.—*Financial Times*, Oct. 19th.

There is another and more serious side to the question, however, and that is the alarming growth of fatal street accidents since the regulation became operative. According to the latest available statistics, fatal street accidents have increased by 25 per cent. during September and October (up to the 17th) compared with the same period last year. Sixteen people were killed during the week ending October 17th, compared with five in the corresponding week of 1913.—*Evening News*, Oct. 27th, 1914.

It is worth noting that the Commissioner of Police has had to draw attention to the fact that the reduced illumination considerably increases the possibility of danger arising from vehicular traffic. The London General Omnibus Co., also, have recently taken the step of largely diminishing the number of buses in London streets, and it is stated that they will now cease to run at an earlier hour than hitherto.

Outside Shop Lighting.

Illuminating engineers are finding much food for thought in the present state of partial lighting of London at night. The conditions of semi-darkness, wisely enforced by the authorities with the object of thwarting any night attack by air on the Metropolis, are bringing out several interesting and important points regarding street and shop window illumination. In the first place, it is clear that in the past there has been much waste of light through this not being concentrated on the contents of the shop windows. The resulting glare has been bad for the eyesight of passers-by, and now aerial observations have shown the glare of unshaded shop lights to be potentially dangerous by facilitating aerial attack. It is quite likely, therefore, that one of the results of the present war will be less glare in our streets, accompanied by more efficient lighting.

The screening of lights from observation by aircraft has been rendered particularly necessary by recent advances in illumination, such as the high-power half-watt lamp, the flame arc, and high-pressure gas lighting, for which electrical and gas engineers have been responsible. In the present conditions it would have been very advantageous had there been more widely adopted the system of individual control of electric street lamps that has been described by the President of the Institution of Electrical Engineers. —*Daily Telegraph*, Oct. 12th.

The Sober Feeling.

The fall of Antwerp, the renewed stream of suffering refugees, the stubborn resistance of the German forces in France, the absence of any of the dramatic "counter-strokes" with which gossip has busied itself, and not least perhaps the physical influence of an abnormally darkened London, all combine to make us a little subdued.—*Pall Mall Gazette*, Oct. 13th.

But in spite of police orders for a further reduction of street lighting, the average Londoner does not take the Zeppelin seriously, though he admits that some at least of the vessels might evade the vigilance of our forces and reach us. The Zeppelins may come, and they may not, but the chance of their coming does not affect the state of mind of the population half as much as the dreary aspect of London after dark. —*Westminster Gazette*, Oct. 13th, 1914.

In a letter to the *Times* of October 21st Sir Edwin Ray Lankaster expresses doubt whether the diminution in danger from a night attack is sufficient to justify the "serious danger and suffering which it certainly causes to the inhabitants of London. Not only is there a danger of street accidents but in suburban districts necessarily an immunity for criminals who may take advantage of the darkness." "But a more serious danger than either," he adds, "is the creation of depression and a certain brooding terror in a population already subjected to a

severe strain by the horrors of war." Sir E. Ray Lankaster also suggests that "an increase in number of specially brilliant lamps and their arrangement in rows or in masses, so as to mislead the invader as to the topography of the city below him would probably do more to baffle the enemy than the ostrich-like attempt at concealment by partial, though most inconvenient and fear-provoking suppression, of the normal street and shop lighting."

Zeppelins and the Bridges.

If the Zeppelins should come to London, I am right in the line of fire from them, since apparently it is expected that the bridges will be the first to engage their attention. Living on the river bank within bomb shot of one of the busiest bridges spanning the Thames, I was ordered on Saturday to extinguish all lights that reflect on the water, otherwise the police would cut off the current altogether. Later in the evening I imagined that the worst was about to happen. The southern end of the bridge was in complete darkness and dashing about in the middle of the roadway, and at considerable personal risk, were two special constables brandishing their electric torches as a signal to approaching motor traffic to stop. Their lights must be extinguished while crossing the bridge, but now and again the driver, thinking he was being trapped for fast driving, made good his escape, but only to be hauled up and remonstrated with at the other end.—*Westminster Gazette*, Oct. 13th, 1914.

Grievances and Obstinacy.

The people who are chiefly interested in the suppression of light in the streets and shops of London during the dark hours are the suppliers of the means by which it is obtained; and they are the people who instead of complaining, have done their best to help the authorities. What is the good of complaining? Loyality to country, and assistance to the authorities in its protection have first claim upon us.—*Journal of Gas Lighting*, Oct. 27th.

From our own observations and inquiries we are not at all persuaded that the people, as a whole, either resent the order or experience any particular inconvenience from the diminution of public and shop lighting. Everybody knows the reason for it, and must repose sufficient confidence in the responsible authorities to acquiesce in the regulation without grumbling. Indeed, the attitude of the public in this regard is such as to suggest that even after the official prohibition shall be withdrawn, it may be possibly a long time before the former extravagance of street illumination will be resumed.—*Gas World*, Oct. 31st, 1914.

Effect on Shopping-Trade, Theatres, and Publishers.

Naturally the diminution of light has already had a considerable effect on the shopping, and as the Christmas season approaches this will become more marked. According to the *Times* the Early Closing Association recently held a meeting at which it was suggested that all shops should close after 7 p.m., and it was thought that the Chief Commissioner of Police might be induced to allow them to show their lights up to that hour.

The theatres likewise are finding that the gloom keeps people away in the evening and the experiment is being tried of holding more matinees and fewer evening performances. The tendency is towards people spending their nights at home. According to the *Daily Graphic* publishers ought to benefit. "Night clubs are now as dead as mutton. . . . It should certainly be a studious winter. A lot of books will be needed and indoor games."

Why the Lights are Screened.

My own theory is that the switching off is intended not to hide London from an airship, but to prevent the airship being hidden from us. One of the joys of living in the country is that the night-sky is visible. In London, thanks to the flood of light which rises to the clouds and is reflected downwards, the firmament is nothing but a hazy glow. Behind this impalpable screen an airship or an aeroplane could float concealed.—*Electrical Industries*, Oct. 21st, 1914.

Regulations to Continue.

The *Evening News*, as a result of inquiries from the Police, learns that the Order made by the Secretary of State under the Defence of the Realm Act expiring at the end of the month (October) will almost certainly be renewed. It is referred to "as having a grave effect in the business and social life of the capital" but is apparently regarded by the authorities as imperative for the safety of London.

CORRESPONDENCE.

THE LIGHTING INDUSTRY AND THE WAR.

October 13th, 1914.

DEAR SIRS,

In reply to your letter, we beg to inform you that business in our "Crompton-Blondel" Flame Arc Lamps has not din inished to any appreciable extent due to the war. We have received a large number of orders for this season's factory lighting, and we also have many impending orders for our Flame Arc Lamps, the latter orders simply awaiting settlement of a few details relating to financial matters or technicalities.

We always carry a large stock of carbons suitable for our lamps, and are now making arrangements for the supply to be continued and to replenish our stock.

We have orders in hand which will keep us fully employed for many months, working extended hours.

Yours faithfully,

For CROMPTON & CO., LTD.,
THOMAS BRITTEN,
Manager.

October 25th, 1914.

DEAR SIR,

The effect of the war has certainly caused a great deal of disorganisation in trade, and the present police regulations regarding the lighting of London naturally operate in the same direction. The effect of the war (if it does not last too long) should ultimately be good, but is causing inconvenience just now.

The chief trouble we are finding is in obtaining varieties of glassware, such as the heat-resisting globes for high candle power lamps, and decorative glassware of the type used with semi-indirect fittings. There is a good stock of these in hand, but there may be some question how to replace them when exhausted. This is a matter for our glass manufacturers to tackle. No doubt if foreign patents were set aside people could be found willing to start new processes of glass manufacturing and make extensions in their factories if backed up by the Government; but they naturally hesitate to do so in view of the uncertainty as to what will happen when the war is over. Besides this, it stands to reason that in any case it would take time for manufacturers here to become as expert in making these varieties in glassware as the firms of the Continent—who have had a monopoly for so many years.

Yours faithfully,

A. E. PODMORE.

34, Charles Street, E.C.

October 26th, 1914.

DEAR SIR,

With reference to your enquiry as to the effect that the European War has had upon our business, I am pleased to be able to state that it is on the whole satisfactory.

In some quarters it has fallen off very considerably, but this has been more than compensated by increased activities in other directions.

My own impression is that in the course of a few months things will improve all round.

One reason for the increase is no doubt due to our being very little hampered in getting supplies owing to the fact that our Lamps and Fittings are manufactured entirely in this country. We have, however, in common with all other manufacturers of incandescent Lamps, experienced some little difficulty in obtaining regular supplies of mantles and glassware, the bulk of which, prior to the war, we obtained from Germany and Austria. I am glad to be able to state, however, that the efforts of English manufacturers are gradually overcoming this trouble, and they will no doubt in the near future be able to entirely replace the articles formerly obtained from abroad. Owing, however, to the very

large demand for articles of this kind, it will necessarily take some little time for things to settle down.

Yours faithfully,
For The UNITED KINGDOM LIGHTING TRUST, LTD.,
J. E. EVERED,
General Manager.

October 28th, 1914.

DEAR SIR,

With reference to your inquiry as to the effect of the war on our business, so far as I am able to foresee my Company will not be adversely affected. We are exceptionally busy at the present moment, and quite well placed for goods of our manufacture.

The Bland Burner is British made throughout, as also is our well-known No. 15 Blanlite Outdoor Lamp, made in enamelled steel or copper. About four years ago I determined to get out a lamp suitable for outside lighting which would compete successfully with the many German outdoor lamps which were being offered to British buyers: it was very favourably received, and is now in wide demand. The War Office took it up and have placed one or two very large contracts for it. Seeing that all the metal work and the porcelain fireclay parts of our lamps and burners are made here we are naturally not troubled by any difficulty in supplying.

My own belief is that the war will result in a great transference of business to this country, although at the moment manufacturers are having a strenuous and difficult time in accommodating themselves to the situation. This applies particularly to the glass manufacturers. The glass for our well-known burners and lamps is being manufactured in Great Britain, and whilst the quality of the glass at the moment is not equal to that which has been manufactured in Austria and Germany, big strides have been made during the last few weeks in the right direction. Of course the initial difficulties in competing against foreign-made glass are considerable, and until it can be made in the enormous quantities in which it is manufactured on the Continent, it may be difficult to produce it at anything like the price at which it has been previously offered by the Continental makers. This does not apply, however, in every case: I am already producing one commodity in glass at the same cost as which it was sold to us from the Continent before the war.

I see no reason why in many other departments we should not hold our own, providing the Government assist manufacturers by preventing similar goods in the future being "dumped" into this country.

Yours faithfully,
THE BLAND LIGHT SYNDICATE, LTD.,
F. J. GOULD,
Managing Director.

October 28th, 1914.

DEAR SIR,

Our experience since the war began is satisfactory—in fact, our output is considerably larger than it has been in normal times. Our business is so varied that any falling off in one direction is compensated by an increase in another. At present orders are coming in very satisfactorily, and we anticipate seeing a considerable increase in our export department very shortly.

We may, as an instance, give you the fact that we have opened a large number of new accounts that have approached us voluntarily with their requirements. This is no doubt accounted for by the fact that British firms are anxious to do business with British Wholesale Houses.

We have hitherto made a point of dealing in British-made goods as far as we possibly can—foreign-made goods always receiving last consideration—and this accounts for the fact that we are not experiencing any serious deficiency consequent upon the present unfortunate state of affairs. One effect of the war will certainly be that many articles previously manufactured mainly abroad will have to be made here.

The section of our factory devoted to glasswork, &c., seems likely to increase considerably owing to the demand that has sprung up for British glass.

We might mention that we are interested in a glassworks just re-opened after the furnaces had been closed down for several years, by which means we hope to be in a position to supply unlimited quantities of British glassware of all descriptions.

We quite appreciate that now is the opportunity offered to British manufacturers to capture German trade, and we are determined to see to it that we get a good share of the business as far as the lighting world is concerned.

Believe me,
Yours faithfully,
A. MATTON.
(For J. & W. B. SMITH.)

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

NEW HOLOPHANE PUBLICATIONS.

DURING the past month we have received from **Holophane Ltd.** two novel publications, namely, a new catalogue relating to Holophane glassware for gas, and a leaflet on Fittings for Half-Watt lamps.

The gas catalogue is really a new thing in publications of this kind. The cover is ingenious in design, and the interior is printed on mat art paper in quite effective style. The introduction gives a general account of Holophane glassware and explains how it complies with the fundamental requirements of good lighting. In addition there is a variety of data of general interest.

Following this we have a complete series of lighting units arranged and described in a most methodical way. On the left-hand pages there are short and pithy paragraphs with such titles as "Good lighting a necessity," "Rule of Thumb versus Rule of Science," &c On the right-hand pages illustrations of the various units are shown and beside them the corresponding polar curves of light-distribution (*both* the curve of the mantle alone and of the same mantle equipped with glassware being given). Lower down on the page we have tabular data enabling the horizontal illumination at any distance from a unit of this kind to be determined.

Finally there is a series of typical Holophane fittings for use with gas.

During recent visits to firms dealing with gas specialities we have found this catalogue widely known and appreciated, and there is little doubt that it will give a considerable impetus to gas lighting, for at the present moment the gas industry is fully alive to the advantages of more scientific methods.

We can recall several American publications, notably that issued by the Welsbach Co. in New Jersey, in which the subject has been treated in a most useful way, but we believe that this new publication issued by Holophane Ltd. will be found to be unique among literature on scientific gas lighting in this country.

The second pamphlet on fittings for Half-Watt lamps is a smaller affair but is also arranged on a novel plan. Each page contains pictures of various units, dimensions and prices, and there is also a diagram showing at a glance the effect of the unit in altering the distribution of light from the bare lamp. Among the types shown we notice the semi-indirect prismatic bowl and the Excellite unit, complete with special Holophane canopy.

LIGHTING OF A RIFLE RANGE AT THE GUILDHALL.

A short time ago we described the gas lighting of a Rifle Range. By the courtesy of **Benjamin Electric, Ltd.**, we now give two illustrations of a range at the Guildhall, which is lighted by metal filament lamps in Benjamin Parabolic (45°) reflectors.

The two photographs will explain how the lighting is done. There are two rows of movable targets (controlled from the firing end). They are lighted by two rows each containing four 55-watt tungsten lamps in metal parabolic reflectors. Behind each row of reflectors is a horizontal black screen, and the walls of the room are also black. The result is that the men firing see the targets brightly illuminated against dark background and surroundings; the lamps are concealed from view and there are no objects visible brighter than the targets. This would seem to be a point of fundamental importance in lighting rifle ranges. Even under the best conditions it requires good sight to see the bull's eye on these ranges quite distinctly, and any surrounding unscreened lights, either in the direct range of vision or seen "out of the tail of the eye," have at once a distracting effect on vision. In this case there is one lamp installed between the firing point and the target, but it is concealed from view and in any case is only turned on when the range is not being used for firing, but is visited for cleaning purposes, &c.

The next question that arises is the amount of illumination required on the target. In this case the illumination can be modified by turning on more or fewer of the lamps, and by moving them backwards and forwards. With all the lamps on a value of 20—25 foot-candles can be obtained, which seems to be ample. Indeed it is possible that *too* high an illumination would be a drawback, as it might lead to "irradiation" (*i.e.*, an apparent encroaching of the white surrounding over the central black "bull"—a species of glare).

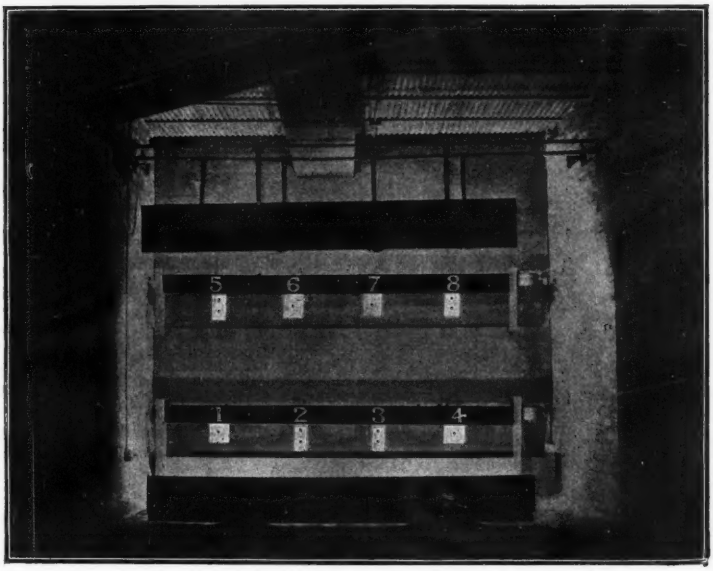
Another important point is that the illumination should be uniform. Any deficiency in this respect soon reveals itself in a habitual preference on the part of visitors for the best-lighted targets. Moreover, in firing at travelling targets it would not be satisfactory to find them continually moving out of a brightly illuminated region into a darker one, and *vice versa*. The eye would have to accommodate itself to these changes, which would appreciably affect the aim.

The lighting of this range appears to have been very carefully considered with a view to avoiding these defects, and it is even worth a visit from rifle-range instructors interested in the lighting question.

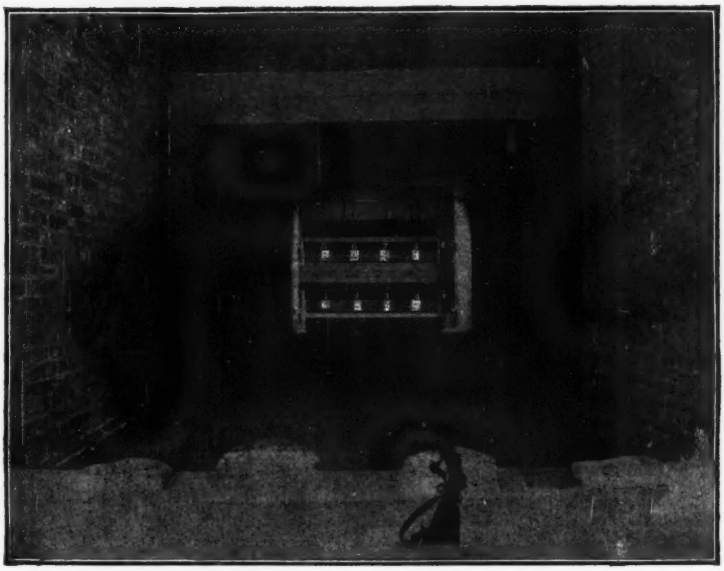
[We had recently an opportunity of inspecting the factory of the Benjamin Electric, Ltd., at 1a, Rosebery Avenue, E.C., where we saw some of the Benjamin Reflectors in the course of manufacture. They are entirely made in England, and the process of the stamping out and finishing is a much more complicated one than the ordinary man in the street would suppose.]

The Wardle Engineering Co., Ltd. (Deansgate, Manchester), send us a copy of the latest catalogue of lanterns and fittings. On the front is a distinctly interesting view of an Eastern city in which modern street-lighting centrally suspended units are installed—a rather curious illustration of the mixture of the old and the new. Besides street-lighting fittings, however, the catalogue contains a series of semi-indirect units for half-watt lamps, among which the "Workslite" fitting for factories strikes us as a particularly useful type.

We understand that Mr. H. Staniforth has left the staff of Messrs. W. Sugg and Co., Ltd., to take over the London Office and to act as the Southern representative of Messrs. Jas. Milne & Co. Ltd., the well-known manufacturers of gas plants, meters, high pressure gas lamps, &c., at 59, Farringdon Road, London, E.C.



View from close up, showing targets lighted by two rows of concealed lamps at top and bottom.



View from the back, from whence the movable targets are controlled.

THE RIFLE RANGE AT THE GUILDHALL.
Lighted by concealed lamps in Holophane Benjamin Steel Reflectors.

MAZDA HALF-WATT FITTINGS.

In our last number we gave an account of some new fittings for half-watt lamps recently introduced by the **British Thomson-Houston Company,** and manufactured entirely in this country. We now give a few additional examples of such fittings, the polar curves of light distribution being added in each case.

Fig. 1 shows a simple fitting comprising a half-watt lamp in Alabas glass globe. Owing to the great brilliancy of the half-watt filament it is obviously desirable that it should be screened by diffusing glassware of this kind. The chief characteristic of the Alabas glass is that the globe appears uniformly bright all over, giving a very soft effect ; and yet the loss of light is comparatively small. A unit of this kind distributes the light more or less uniformly in all directions. The next unit (Fig. 2.) is of a semi-indirect type. It consists of a diffusing glass bowl underneath and a reflector above so arranged that the actual filament is always screened from the eyes. Of recent years there has been a great demand for semi-indirect lighting, and this demand has been accentuated by the coming of the half-watt lamp. Another point to be noted is that the high efficiency of these lamps rendered the loss of light involved in a semi-indirect unit of small importance. For it is now possible to substitute semi-indirect lighting with half-watt lamps for direct lighting with tungsten lamps of the ordinary variety and yet to make a saving in the energy consumption for the same illumination. A point to be noted in connection with these fittings is that the results obtained are practically independent of the nature of the ceiling.

We now come to the radial wave reflector shown in Fig. 3. This forms a unit especially intended for the lighting of large open spaces, wide entrances, and lofty buildings. It consists of an enamelled corrugated steel reflector so arranged as to be entirely weather-proof. the corrugations being designed to break up and distribute the light and to avoid striations. It will be observed that the candle-power is practically equal in all directions in the lower hemisphere. Ample ventilation is provided, and free access for wiring can be readily obtained by removing the cap at the top of the iron housing.

It will be seen, therefore, that the British Thomson-Houston Company have now on the market a considerable variety of half-watt fittings, and there are plenty of appliances for making the best use of these lamps.

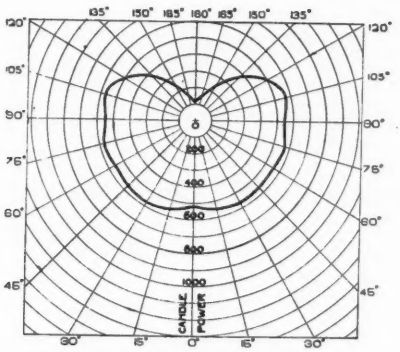
MAZDA HALF-WATT LAMPS FOR MOTOR-CAR LIGHTING.

We have before us a list issued by the **British Thomson-Houston Co., Ltd.,** dealing with Mazda " Half-Watt " lamps for motor-car use.

We have previously referred to these new lamps, and the illustration shows their general appearance. The metal filament was of course a great advance on the old carbon filament for such purposes, and most of the difficulties involved in making low-voltage battery lamps with carbon filaments disappeared when the metal filament became available.

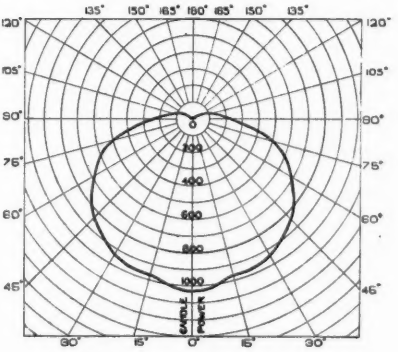
Next, attention was paid to the *shape* of the filament, and the bunched spiral arrangement gave us something much more nearly approaching the ideal " point-source " desired for optical purposes. Now comes the half-watt automobile lamp with its coiled filament in a gas-filled bulb which is stated to be *eight times* as efficient as the old carbon filament lamp. The effect of this in headlights will doubtless be very striking, and we should think that it will find other important applications in connection with mirrors as " flare-lights," and possibly for portable searchlights.

FIG. 1.—Alabas Lantern for Mazda half-watt lamp.



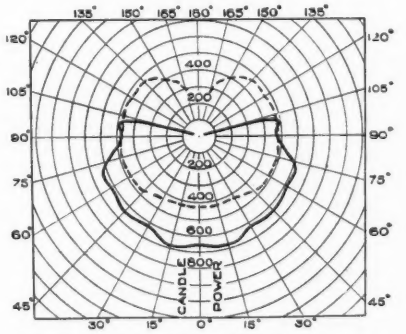
Polar curve of Mazda half-watt lamp in Alabas globe.

FIG. 2.—Mazda 500-watt 100-volt lamp in Lumino semi-indirect fitting.



Distribution of light from Lumino semi-indirect fitting.

FIG. 3.—Mazda half-watt lamp in 24-in. Radial Wave Reflector.



Dotted curve shows distribution of light from bare lamp. Full curve shows distribution from same lamp in Radial Wave Reflector.

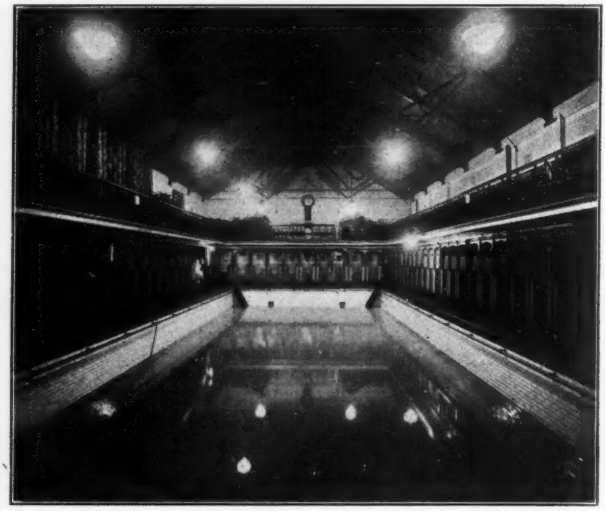
MAZDA HALF-WATT FITTINGS.

THE GAS LIGHTING OF A SWIMMING BATH.

IN a swimming bath a claim can be easily made for good artificial illumination. Any one who has patronised the London baths knows how the crowd begins to stream in after office hours, so that there are often more people there during the hours when artificial illumination is needed than there are during the day time.

The lighting requirements are obvious and fairly simple. The lamps are necessarily hung high up above the water and should be sufficiently numerous and powerful to flood the room with light in every part, not only to illuminate the water but to throw light into the dressing rooms as well. Nor should it be forgotten that during the season there may be evening displays, when the galleries will be crowded.

The presence of an overhead skylight makes it essential to suspend lights from the girders, and no help can be relied upon from reflecting surroundings above the lamps. It is therefore important that they should be furnished with the right type of reflectors. With a crowd of bathers below and additional people in the galleries up above good ventilation, *without draughts*, is an important item. In this respect it is claimed that gas lamps have the advantage of promoting an upward current and thus assisting the removal of used-up air from below.



The illustration, kindly lent to us by the **Gas Light & Coke Co.**, is a good example of a bath lighted by powerful gas lamps.

A VISIT TO SOME OF THE LEADING ELECTRIC LAMP FACTORIES NEAR LONDON.

SINCE the war broke out considerable interest has been taken in the electric lamp situation. Owing to the stoppage of Continental suppilies British lamp companies were faced by an opportunity of considerably increasing their output.

Until an authoritative investigation of the situation has been made it is difficult to estimate the total amount of lamps required per annum in this country with any precision. Estimates, however, place the figure at twelve to fifteen million, and it is suggested that during the war quite another ten million might be exported to the Colonies and to neutral countries. It is evident, therefore, that there is plenty of ground for expansion.

With a view to ascertaining how things are progressing we recently visited the lamp works of some of the leading makers, namely, the Osram Works of the General Electric Co., the works of Messrs. Siemens Bros. at Dalston, the Brimsdown Lamp Works, and the factory of the Edison and Swan United Electric Lamp Co. at Ponder's End, and the B.T.H. works at Rugby.

In every case it was stated that the demand for lamps since the war began had been quite unprecedented. The view was expressed that the lamp-makers in this country would be quite equal to meeting the new conditions. In what follows we give our impressions of these visits. We have arranged the matter so as to avoid unnecessary repetition. Many processes are now standardised and are executed in very much the same way in all the factories. We have therefore tried to arrange the descriptions so that, taken together, they give a good picture of the making of a lamp; and in dealing with each factory have mentioned points that struck us as being of special interest.

It may be added that the best lamp works seem to have reached a high standard as regards ventilation and hygienic conditions for employees, all the works visited being good in this respect.

THE OSRAM LAMP WORKS.

In our last issue we gave a general account of our visit to the Osram Lamp Works. In this number we are adding some fuller particulars of the actual processes of manufacture involved. We will take in turn the various items.

Bulbs and caps.—Lamp-bulbs, as stated in our last issue, are turned out in considerable quantities from the Lemington Glassworks, which has fulfilled a most useful purpose since the war began. Caps are also produced outside the Osram works. Otherwise everything is done on the premises.

Drawn tungsten filaments.—In our visit we were shown the process of drawing tungsten filaments in actual operation. Tungsten powder is compressed into a thin rectangular bar which is first subjected to the high temperature of a hydrogen flame to remove all impurities and then to the passage of an electric current bringing it to a more solid state. It is then hammered under heat into a long thin rod of ductile tungsten and is gradually drawn out to the required thinness. The wire obtained is wound on reels for future use.

Lamp stems, tubes and spider.—The support of the filament involves the use of glass tubes and rods. The tubes are cut to required length and fed into an automatic machine (one of the most interesting in the works) which puts a flange on each. The centre rods are cut and shaped in the blowpipe and are

subsequently attached to the flanged tube, through which come the leading-in wires.

The next step is to mount filament supports at top and bottom of the centre rod, thus forming the "spider." These supports have a certain amount of spring so as to hold the filaments taut. This can be done by hand, but an ingenious machine has been made which inserts a set of spring supports at one operation. The loops in the supports are made afterwards and the whole spider is carefully adjusted, preparatory to winding on the filament.

bination of machinery and hand labour. The bulbs are exhausted, six or eight at a time, and the operators, who sit on trolleys running on the rails of a small tramway, are able to pass rapidly up and down and supervise several sets of lamps simultaneously.

Samples from each batch of lamps are put through life tests, and the candle-power of every lamp is carefully tested in the photometer room.

Capping.—The final process is the placing on of the cap and the soldering

Fixing stems on exhausted Osram lamps.

Winding filament and inserting cage in bulb.—The drawn wire filament is easily wound on by hand, and it is interesting to see how deftly this is done by the operator. Next a current is sent through for a moment and the filament is then held by the spring supports with the requisite tension.

The "cage" as formed by the previous operations is now ready for insertion in the bulb. The rough flange at the end of the bulb is first cut away and the cage is inserted with the hollow stem upwards, the lower part of the bulb being then welded on in the blowpipe.

Exhausting.—The exhausting department affords a good example of the com-

in of the leading-in wires. The caps are on the lamps under heat which is supplied by a special electric heater. The machine which places the requisite amount of cement in each cap was specially designed at the Osram works. The General Electric Co., it is also stated, is now making its own caps.

After capping the lamp is complete, but must pass a final inspection before being cleaned, branded, and packed away.

Such is a brief history of the making of a metal filament lamp. The description, necessarily short, does not do justice to the wonderfully ingenious automatic machinery used for many of the processes, which must be seen to be appreciated.

Life-testing rack for Osram special lamps.
(Huntalite, Tubolite, Axial, &c.)

Tungsten wire-drawing for Osram lamps.

A DECLARATION.

WE have also received from the General Electric Co., Ltd., a copy of the well-known Declaration which appeared in the *Times*, the *Daily Mail*, and other papers, to the effect that the Osram Lamp Works employs only British workpeople, and is a subsidiary of the General Electric Co., Ltd., more than 94 per cent. of whose capital is owned by British shareholders.

THE MAKING OF WOTAN AND TANTALUM LAMPS.

A Visit to the Works of Messrs. Siemens Bros. at Dalston.

Through the courtesy of Messrs. Siemens Bros., Dynamo Works, Ltd., we were recently afforded an opportunity of seeing Wotan and Tantalum lamps being made at Dalston. The chief point of interest in this case is that both varieties of metal filament lamps are manufactured simultaneously; there are slight variations, but speaking generally the processes are similar. Both lamps utilise a drawn wire filament.

All the manufacturing operations are very interesting, and the amount of raw material passing through the various departments gives the impression that the factory is very busy. We are informed that orders are coming in very much as usual, and our attention was drawn to certain exceptionally large orders which clearly emphasised the success which has attended the manufacture of these particular types of lamps. Lamps for traction work have been made a speciality by Messrs. Siemens—the Tantalum Traction Lamp being extensively used at the present time on the majority of the leading electric tramways and railways. Quite recently the Wotan Traction Lamp has been introduced with a Helical Drawn Wire Filament, and as this lamp is rather more efficient, it is expected that a large demand will be experienced. In comparison, Tantalum lamps are cheaper in initial cost, and it is therefore to be assumed that in cases where energy consumption is not a very important factor these lamps will still be used.

The first operation in making the lamps is the flanging of the glass tube through which the leading-in wires pass. This is accomplished by means of two types of machine—one of which performs this operation only, and the other a series of operations. In each case, however, the glass tube is brought into contact with a blow-pipe flame, and when sufficiently hot, a device is pressed into it so as to form a flange or funnel.

The leading-in wires are brazed on to short lengths of platinum wire which, in turn, are attached to copper electrodes. These are subsequently inserted and sealed into the flanged tube, together with the foot of the spider. This spider consists of a small glass rod carrying radial wires at each end. At the extremity of each wire is a hook, and the drawn wire (either tungsten or tantalum) is eventually wound by hand on these supports. There is, however, a difference in the spider according as tantalum or tungsten wire is used. In the Wotan lamps the lower supports are of thin and pliable molybdenum wire which has a certain amount of spring so as to keep the wire filament taut, and the top supports are of relatively stout "constantan" metal. But when the tantalum wire, which is stronger, is used, both the upper and lower supports may be of copper.

The spider, the leading-in wires, and the flanged tube are assembled together and connected in a specially constructed machine, the portions that require to be welded being softened in the flame and then squeezed together so as to grip the leading-in wires and make a hermetic seal with the platinum.

In the winding-room the operator first adjusts the hooks of the spider and then measures off the required length of tantalum wire, and it is then wound by hand over the copper supports, a mere "pinch" being sufficient to attach it to the ends of the leading-in wires.

In connection with the Wotan Tungsten Lamp it is found necessary to "form" the filament so that it falls into correct lengths for winding on the spider. This is accomplished by two distinct methods—one a hand device, and the other an automatic machine.

What has been said above refers to lamps of the ordinary standard type. There are also varieties such as the special Helical Filament lamp (which gives a practically uniform distribution of light except in the direction of the cap), the Wotan Traction type, and the half-watt lamp utilising a filament of spiralised tungsten wire. In our visit we saw spiral wire of this kind being prepared for the various forms of lamps mentioned above.

After the operations described above, the spider with the filament already wound is inserted into the glass bulb, to which a stem has already been attached to facilitate exhausting. The lamp is then sealed at the neck, or cap end, and passed on to the pumping machines for exhaustion. This process is carried out in two stages, the lamps being first put on to a rough vacuum pump, and afterwards on to a finishing pump so ensure obtaining a perfect vacuum. During this operation, a current is passed through the filament so as to drive off any occluded gases. While actually on the pumps the bulb is sealed at the junction to which the glass stem has been affixed—thereby making the pip of the lamp.

When finished the lamps are aged by being overrun for a certain period, and

Stemming the bulbs of Wotan lamps.

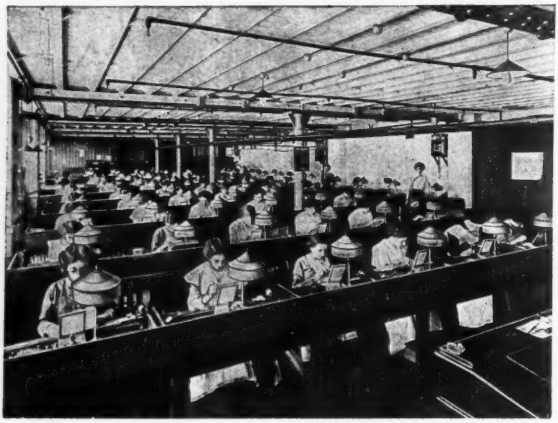
Making the spiders used in Wotan lamps.

THE MANUFACTURE OF TANTALUM AND WOTAN LAMPS AT DALSTON.

before being passed every lamp is subject to a photometric test. The photometer is set to read the standard candle-power and the corresponding voltage and current are measured. (The writer considers himself fairly at home with a photometer, but he was nevertheless impressed by the machine-like celerity with which the girls in charge of this operation went through their work. To test several thousand lamps a day in this manner is certainly a feat !)

Finally we have the capping and finishing processes, after which the lamps are given a final vacuum test with a transformer with a secondary pressure of 10,000 volts. There is also a final inspection to make sure that the lamps are correctly classified as regards voltage and candle-power. Ultimately they are sent to the wrapping shop and the store (where, as a rule, they do not remain long !).

We found our visit a most interesting one, and it was evident that the factory was very busy. Another point that struck us was the way in which all essential processes were duplicated by hand and machinery, so that in the event of any breakdown or temporary difficulty the chain of operations could still proceed without intermission.



Winding filaments. Note the special stand lamps equipped with conical shades which completely conceal the filaments from the eyes of workers.

The illustration on the right shows the Wotan Traction lamp with helical filament to which reference has been made above.

ROYAL EDISWAN LAMPS.

A VISIT TO THE FACTORY OF THE EDISWAN AND SWAN UNITED ELECTRIC LIGHT CO. AT PONDER'S END.

We recently took advantage of a courteous invitation to visit these works where the Royal Ediswan lamps are made. Readers are of course aware that many other things besides lamps (such as switchgear, distribution boards, &c.) are manufactured at Ponder's End, but it is the lamp factory in which we are mainly interested.

These works have an historic interest in view of the achievements of the late Sir Joseph Swan in connection with the invention of the carbon filament lamp. Even now the Ediswan works are unique for the fact that carbon filament lamps at present constitute very nearly *half* the total output. For many purposes carbon filament lamps are still as good as metal filament lamps and they are, of course, considerably cheaper.

FIG. 1.—An Ediswan bulb being produced.

In the course of our visit we noticed that a considerable space is given up to the making of these lamps. In one room there were rows of large jars containing cellulose solution which flowed through glass nozzles of various sizes into hardening liquid and were eventually collected as an elastic fibre. Subsequently these fibres are wound on forms and dried, carbonised by a special process, and finally "flashed" in an atmosphere of hydrocarbon so as to make them uniform throughout.

The mounting of these filaments in the bulbs is the next process but is a fairly familiar one, and we will pass on to the next item of interest—the manufacture of the glass bulbs.

It is well known that with the outbreak of war the problem of obtaining lamp bulbs became a very pressing one. Fortunately the Edison and Swan Co. are in a position to make their own, having glass works which have been in operation for quite a number of years.

There are at present two furnaces in actual use and another larger one will be completed shortly. We were informed that the Company is in a position to manufacture several million bulbs per annum. Our first illustration shows the operation of making a lamp-bulb. The circular furnace contains a number of "pots," each of which contains its respective charge of molten glass. The glass-blower inserts his rod into the pot, draws out a mass of molten material, places this in a mould, gives the necessary "blow," and an Ediswan bulb is the result.

We made inquiries as to the possibility of a scarcity of suitable sand and other materials for glass manufacture owing to the war, but we were assured that this had been foreseen and no inconvenience was anticipated.

Many special forms of bulbs, besides those of the ordinary variety, are made. Large bulbs of the half-watt size can be manufactured, and ornamental types made of opal and variegated glass have long been a speciality.

Readers will recollect, too, that in the early part of this year much interest was taken in the special coloured glass bulbs turned out with a view to producing "Artificial Daylight" with tungsten lamps. We were told that there has been a considerable demand for Ediswan lamps of this type.

As regards the metallic filament lamps, the various processes involved in the manufacture need not be described again and it need only be said that we saw these drawn wire lamps being turned out in considerable quantities and in great variety. It is of interest to mention that besides carrying out all the ordinary operations a certain number of caps for use with lamps have already been made.

The Edison and Swan United Electric Light Co. have always been known for the variety of special lamps they turn out

(such as imitation candles, &c.). We understand that the war has greatly diminished the demand for these "luxury" types of lamps, but fortunately the great demand for the standard forms renders this of little consequence.

We noticed, however, other types in full swing, notably the minute lamps for telephone switchboards (all of which have to pass a test for candle-power!) and other special small lamps used for range-finding in naval gun-fire, which have to stand a very severe test of mechanical strength.

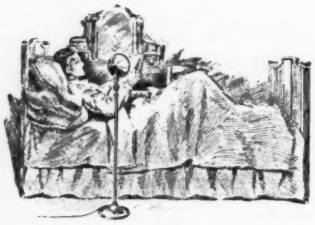
The photometer-rooms and testing arrangements at the Ediswan factory are exceptionally complete. Every lamp has to pass an approximate test with a shadow photometer, and a certain proportion of the lamps so passed are subsequently tested accurately on the photo, metric bench. There are several rooms-one equipped with potentiometer and Pentane standard, rotating lamp-holders, and all the apparatus for accurate photometry.

In one room an Ediswan Half-watt lamp was being tested, in another one the "Downlite lamps" fitted with opal coating over the upper hemisphere; life-tests were in full swing.

In another part of the building the packing and dispatching department was very active. Altogether it was evident that the Edison and Swan United Electric Co. is doing its share towards meeting the abnormal demand for lamps that has arisen in consequence of the war.

SOME RECENT EDISWAN NOVELTIES.

Royal Ediswan Lamps



At the bedside.

By the armchair.

—o—

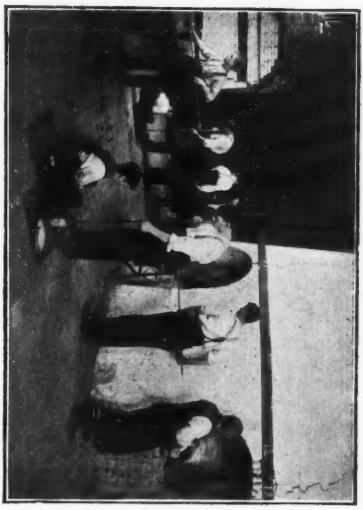
A simple adjustable pedestal lamp described in a recent Ediswan pamphlet.

Facsimile of the cartoon in the *Daily Mail* emphasising the fact that the Royal Ediswan is an "All British" lamp.

Showing the spider on which the drawn filaments are wound.

Flashing carbon filament Ediswan lamps.

Finishing off large-bulb Ediswan lamps.



Lamp bulbs being made in the Ediswan glass factory.

SOME STAGES IN THE MANUFACTURE OF ROYAL EDISWAN LAMPS AT PONDER'S END.

THE BRIMSDOWN LAMP WORKS.

By the courteous permission of the Brimsdown Lamp Works Ltd. (Middlesex) we were recently afforded an opportunity of seeing how "Wirum" lamps are made. This lamp has several interesting features and we were able to see it made from start to finish.

The operations involved in mounting all metallic filaments within lamp bulbs are now fairly well standardised. But the filament used in these lamps is remarkable in that its ductility is produced not mechanically, but by purely *chemical* means. The so-called "drawn wire" filament is gradually pulled out to great fineness. In this case the filament is, so to speak, "pushed out." The metal is first reduced to a convenient plastic condition, and certain materials are added to it which subsequently combine with the tungsten to form highly ductile alloy.

As the filament emerges from the press it is non-conducting except at a very high electrical pressure. But by special treatment, involving the passage of a current at a high P.D., it can be made to change over to a regular crystalline state. The wire obtained is then very malleable. It owes this quality to its regular crystalline structure and, it is claimed, retains it to an exceptional degree throughout the life of the lamp. In the standard form of lamp the filaments are mounted in a series of straight "forks" or "V's." They are then securely attached to their supports by a special metallic paste and subsequently welded into a position by the passage of an electric current. The stem and radial arms carrying the filament are in no way peculiar except that the alternate supports are slightly shorter than the others, the filament being thus brought "in and out" in a somewhat unusual manner. The highly ductile nature of the material seems to be specially useful for small lamps with thick filaments, and we noticed some types with the filament wound in a complete spiral which were highly instructive as instances of the way in which this wire can be bent.

The fact that the lamp is made up of a series of comparatively short lengths of filament joined together, instead of a single continuous length has one advantage, namely that greater homogeneity can be secured. For it is practicable to reject any length which is irregular and therefore a possible source of weakness; whereas in the case of a lamp using a continuous length of wire it is a drawback to have to reject this entire filament merely because there is a weak spot at one point. It should be mentioned that the diameter of all Wirum filaments is very carefully gauged and each fork is weighed to standard, before it is passed for use in the lamps.

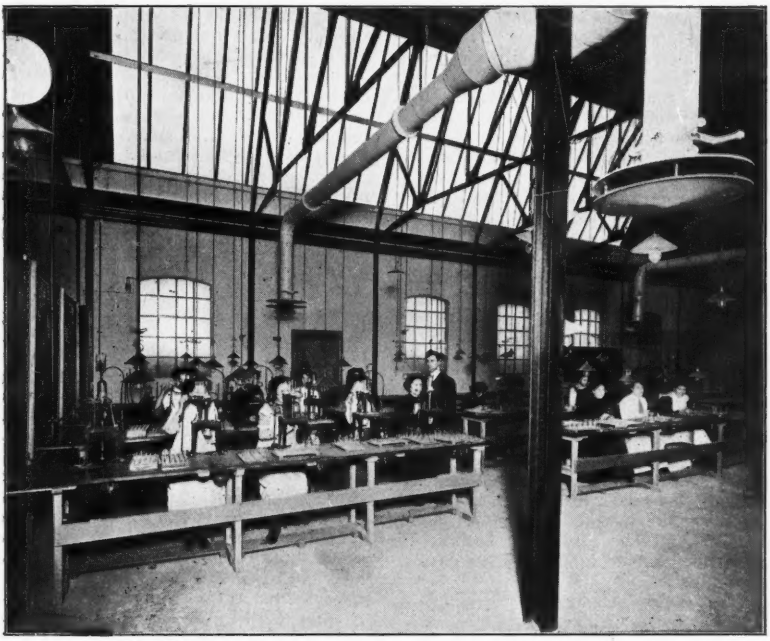
The operations of mounting the filament in the bulb are familiar; we noticed, however, several interesting dodges, among them an ingenious contrivance for removing the surplus glass from a lamp bulb. The lamp bulb is rotated in a series of burners, placed in a semi-circle, and is then applied to a cold surface; whereupon the surplus glass cracks off along the ridge, leaving a very neat edge.

Another point that struck us was the variety of methods of judging the perfection of the vacuum, including a very sensitive pump by which the state of evacuation could be tested at any stage in the process. In a room at the top of the building lamps of many different sizes are assembled on racks for ageing, every lamp being subjected to a quarter of an hour's burning at 10 per cent. overload. Life-tests are also constantly in progress and the result of any alteration in the process of manufacture is soon detected in the photometer room. In addition to special photometric work of this kind it may be mentioned that the candle-power of every lamp that goes out is tested.

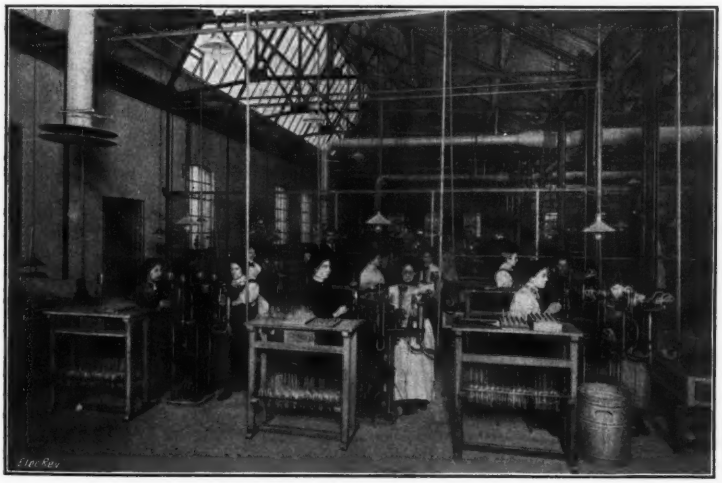
It has been said that the Wirum filament appears to be particularly suitable for low voltage battery lamps. An illustration of this is provided by the special department of the works given up to the manufacture of small lamps for dry cells, the manufacture of which (including blowing the bulbs) is completely carried out on the premises. It was quite a revelation to find how much of this work was being done; we were told that the output already amounted to several million lamps a year and was expected soon to be very much more.

As regards the general character of the works it only remains to be said that there is abundant space and that the employees work under very comfortable conditions. The ventilating plant is unique. The air is driven into the room over surfaces which can be either cooled or heated according to the season of the year.

The visit certainly showed that the Wirum lamp (including the filament) is entirely made in this country, and we were given to understand that this is true of every lamp that has ever been sold in England under that name.



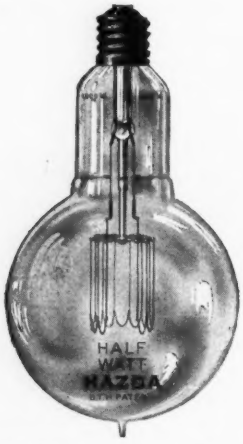
Jointing filaments on to supports of Brimsdown lamps.



Joining lamp bulbs on to the cage.

BRITISH-MADE HALF-WATT LAMPS.

In our last issue we referred to the interesting fact that the British Thomson-Houston Company are actually manufacturing half-watt lamps at Rugby. We take this opportunity of giving a few additional particulars of the way in which these lamps are made. Readers are of course aware that drawn wire Mazda lamps of the ordinary variety are manufactured in large quantities at Rugby, but it was perhaps a revelation to some people to discover how far the manufacture of half-watt lamps has progressed. An important point is that the actual manufacture of the drawn wire is carried out from start to finish, and we understand that the Company has for years produced its drawn wire supply at Rugby. The ores containing tungsten are reduced, the metallic powder melted into ingots and then drawn into the wire by a series of special processes. The finest wire is about 1/2000 of an inch in diameter and the diamond die through which this wire is drawn is so fine as to be undistinguishable to the naked eye. Lengths comprising many thousands of feet of wire are drawn in one piece.



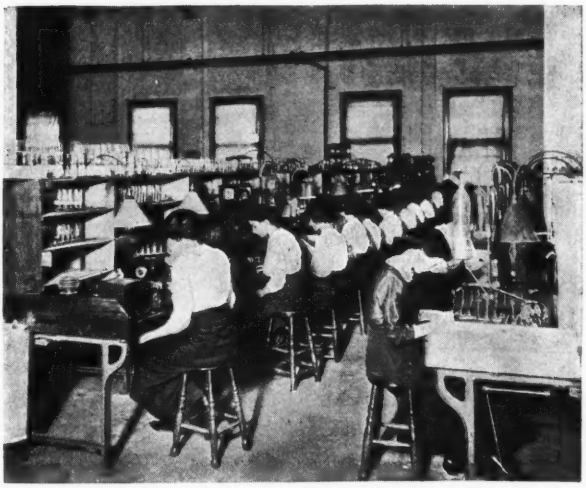
Showing the glass support and method of holding half-watt filaments.

The half-watt filament, as is well known, is composed of stout ductile tungsten wire wound in the form of a spiral. This is accomplished by a special form of machine winding a perfectly uniform spiral but leaving, at regular intervals, gaps for the support of the filament in the finished lamp. The spiral for the low voltage automobile half-watt lamps is wound in a similar manner but on a smaller machine.

The operation for constructing supports for these half-watt lamps differs essentially from that employed in the ordinary metallic filament lamps. The actual filament is much further removed from the cap of the lamp and the glass support is consederably extended. Another distinction is that the glass stem carries at the end a series of radial rods of glass. Each of these rods carries a metal supporting wire, to the ends of which the half filament is attached in a series of loops. All this is done by machinery, and special care has to be taken in the annealing of the glass so that no cracks occur. One point of interest in the Mazda half-watt lamp is the reduction of overall length which is now found possible. The long neck has been considerably shortened, making the lamps appear considerably neater.

The next operation, which differs from those employed for ordinary metallic filament lamps, is the filling of the bulbs with suitable gases, such as nitrogen or argon. During our visit we saw the plant for making these gases in operation, but it is not desirable to describe the process in any detail. In some cases argon is preferable to nitrogen. It is well known that the introduction of gases into the half-watt lamp has the advantage of checking the vaporisation of the tungsten. It has *also* the inconvenient result of cooling the filaments to some extent, but by the use of the concentrated filament this cooling effect is reduced to a minimum, and a higher temperature can be maintained without detrimental shortening of the life such as would occur with lamps of the ordinary vacuum type. In preparing the lamps to receive these gases the bulb is strongly heated in order to dry it completely and in order to drive out all traces of air that may be occluded in the glass or metal within the bulb. During this process the bulb is exhausted with special vacuum pumps so that ultimately a complete dry vacuum is obtained. The inert gases are then led into the bulb in such a way that when the lamp is burning the pressure within the bulb is slightly under that of the atmosphere.

Apart from such technical details, a visit to these factories is an interesting experience on account of the care bestowed on the comfort and health of the workers. Moreover, it is stated that the hourly production of workers does not diminish but actually *rises* as the day goes on.



Shaping and mounting the filaments of Mazda half-watt lamps.

Sealing-in Mazda half-watt lamps.

[This completes our series of notes on the manufacture of electric incandescent lamps. We propose, in a subsequent issue, to deal with the manufacture of lamps and mantles used in the gas industry in a similar manner.—Ed.]

HEAT RESISTING GLASS MADE IN ENGLAND.

ONE of the chief difficulties caused by the war is the supply of heat-resisting glass globes, the manufacture of which has been largely in the hands of Germany and Austria.

In the course of a recent visit to **Messrs. Falk, Stadelmann and Co.** we were interested to hear that they are taking steps to make good this deficiency by manufacturing in England.

Naturally there are obstacles to be overcome. The skill of the Continental workers is the result of patient experiments for generations. Moreover, glassware abroad is made in enormous quantities in order to supply not only Germany and Austria but (in some varieties) practically the whole world, so that it can naturally be produced cheaper.

Yet we may expect to undertake some portion of this business, and manufacturers are already struggling with the problem. During our visit we were shown some heat-resisting chimneys made at works in England which were considered to be as good, if not better, than those made on the Continent. These are made of lead glass but of a hard variety. We were also shown samples of pressed glass globes, and heat-resisting glass without a trace of lead in it.

The manufacture of the very finest qualities of Jena glass is no easy matter. Some of the materials are wanting in this country or could only be made at considerable expense.

Moreover, it does not follow that the materials used in the German furnaces would be equally applicable here.

Manufacturers have, therefore, to buy their experience, and deserve encouragement in their plucky attempt to grapple with the situation. Messrs. Falk, Stadelmann & Co. appear to be making considerable progress. We are assured that the glass manufacturers are not idle, and that, given time, they can do all that is necessary.

BLAND SPECIALITIES.

In a recent visit to the showrooms of the **Bland Lighting Syndicate, Ltd.** (63, Queen Victoria Street, London, E.C.), we noticed some interesting semi-indirect units for gas, particularly one with an ornamental white glass bowl attached to a handsome bronze fitting and giving a very soft, pleasing effect. Owing to the distance at which this is suspended from the ceiling there is no danger of discolouring the ceiling with this unit. When it is desired to mount the unit close to the ceiling a white glass bowl with white enamelled steel deflector above is preferred. It is interesting to see how closely these units resemble those used for electricity, and it is evident that the same methods are now applicable to both illuminants.

Another point that struck us was the increasing use of data showing the distribution of light from various units. The Bland Light Syndicate, Ltd., issue a leaflet showing the three "E," "I," and "F" curves obtained from Bland inverted burners with Holophane reflectors. All these burners are equipped with the well-known Bland protecting hood, which prevents the contamination of the ingoing air by products of combustion. These deflecting hoods can be made of porcelain and manufactured, like the rest of the burner, in this country.

Other things on show include the new 300 c.p. British-made lamp and the No. 15 outdoor lamp, which is an improvement of that introduced so successfully about five years ago.

AN "ALL-BRITISH" FIRM.

We recently paid a visit to **Messrs J. and W. B. Smith** (15-23, Farringdon Road, E.C.), with a view to ascertaining how this firm is being affected by the war. We were told that the output is satisfactory, particularly in the glass section, to which we hope to refer more fully on another occasion.

Messrs. J. and W. B. Smith are a long-established (1839) and essentially British concern—in fact, they used the crossed Union Jacks as a distinguishing mark years *before* the war started.

We were given to understand that the variety of goods shown in the two catalogues given up to gas and electric fittings, is almost exclusively of British manufacture. Probably one result of the war will be that many kinds of glassware, &c., formerly made exclusively abroad, will now be done here.

INDEX, November, 1914.

	PAGE
Correspondence—"The Lighting Industry and the War" [J. E. Evered—F. J. Gould—A. E. Podmore—A. Matton]	519
Editorial .. .. L. GASTER	507
Illuminating Engineering, Summary of Progress during past year	511
"Lights Out"	516
Photo-Sculpture .. .. J. HAMMOND-SMITH	515
Review of Technical Press	542
Topical and Industrial Section :—	
Holophane Glassware for Gas	521
Lighting of the Guildhall Rifle Range	522
Mazda Half-Watt Fittings	524
Lighting a Swimming Bath by Gas	526
The Manufacture of Electric Incandescent Lamps [The Osram Works—Siemens Works at Dalston—Ediswan Works—Brimsdown Lamp Works—B.T.H. Half-Watt Lamps at Rugby]	527
Heat-Resisting Glassware	540
Bland Specialities	540
An "All-British" Firm	540

On this occasion our attention was devoted mainly to the "Silva" lamps (high and low pressure), some highly effective gas-heated irons consuming only 2 cubic ft. of gas per hour, and a series of small compact compressors. Although the firm is best known for its gas engineering (it makes laundry work a speciality), it also deal with electric fittings—a fact that should establish a natural sympathy with the illuminating engineering movement which benefits both methods of illumination.

NATIONAL PHYSICAL LABORATORY.

Report for the Year 1913—1914.

It will be recalled that about this time last year we drew attention to the urgency of the National Physical Laboratory receiving more substantial Government support. We are glad to see from the report before us that the annual grant has been raised from £7,000 to £12,000. But it is still necessary to raise a sum to provide working capital for the Institution and secure the Royal Society against loss in case of deficit. Steps are being taken to bring this point before the authorities.

As usual, the Report refers to many varied and interesting researches in the photometric department. Some experiments are being made on the comparison of "contrast" and flicker photometers. The comparison of the standards of light in use in various countries has been continued, and it appears that the values agree within 0·25 per cent.

At the request of the Local Government Board researches are being made with a view to moderating the dazzling effect of motor-car headlights. The chief principle seems to be to design the headlights in such a way that the beam does not strike the eyes of a person passing the vehicle.

Reference is also made to the work of the Director, Dr. Glazebrook, and Mr. C. C. Paterson, in connection with the Home Office Committee on Industrial Lighting, and to the work of the latter as Honorary Secretary of the International Illumination Commission.

"MODERN ILLUMINANTS AND ILLUMINATING ENGINEERING."

A book with the above title by Leon Gaster and J. S. Dow will be issued by Messrs. Whittaker & Co. early in the new year. It is dedicated to Professor Silvanus P. Thompson, "First President of the Illuminating Engineering Society, in recognition of valuable services rendered to the cause of good lighting."

REVIEW OF THE TECHNICAL PRESS.

THE chief topic in the British journals is the **Diminished Lighting of London in War Time,** and in the American press the **Convention of the Illuminating Engineering Society.** A contribution by P. S. MILLAR (*Journ. of the Franklin Inst.*, Oct.) states some general truths about illuminating engineering in diagram form. He also gives various diagrams reviewing progress in gas and electric lighting from their inception.

F. M. WELLER (*Elec. Rev. and Western Electrician*, Oct. 17th) describes some novel and effective bits of **spectacular lighting,** including the use of concealed lamps to light up statues and monuments, which he illustrates by photographs.

An article of exceptional interest is that summarising some new developments in the **magnetite arc lamp** (*Elec. World*, Oct. 3rd). The use of more titanium in the electrodes has resulted in an efficiency near 0·6 watts per mean spherical candle, but the life of the electrodes is diminished from 350 to 150 hours. By using a new prismatic globe, smooth on both sides, the polar curve can be changed into one excellently adapted to street lighting. A recent patent in the United States refers to the use of **uranium for lamp-filaments,** but it is not clear what advantages this metal possesses for the purpose.

Among papers on gaslighting, we may note that of CONROY (*Am. Gaslight Journ.*, Aug. 31st), who discusses the design of elegant fixtures and makes special reference to **semi-indirect lighting,** and BABCOCK (*Am. Gaslight Journ.*, Sept. 28th), who gives some interesting **statistics** comparing the number of gas and electric lamps in various American and European cities.

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Artificial Daylight. (*Elec. Rev. and Western Electrician*, October 3rd).

The Advance of the Arc Lamp (*Elec. World*, October 3rd).

The Nature of Reflection. (*Elec. World*, October 10th).

Coloured Screens and Light Filters in Photometry (*Elec. World*, October 10th).

"Amateur Illuminating Engineering" (*G. W.*, October 31st).

Harrison, Haydn T. Street Lighting Requirements (*Elec. World*, October 10th).

Latta, N. Liquid Gas (*Am. Gaslight Journl.*, October 12th).

Millar, P. S. The Art of Illumination (*Journ. Franklin Inst.*, October, 1914).

Weller, F. M. Illumination Features of Baltimore's Star-spangled Banner Celebration (*Elec. Rev. and Western Electrician*, October 17th).

The Lighting of London in War Time (*J. G. L.*, September 15th, October 13th).

The Eighth Annual Convention of the Illuminating Engineering Society (*Elec. Rev. and Western Electrician*, October 8th; *Elec. World*, October 3rd, 10th; *Am. Gaslight Journ.*, October 5th).

Uranium for Lamp Filaments (*Elec. Rev. and Western Electrician*, September 26th).

Large Lamps for Intermittent Service (*Elec. Rev. and Western Electrician*, September 26th).

Thirty-fifth Anniversary of Electric Lighting by Incandescent Lamps (*Elec. Rev. and Western Electrician*, October 10th).

Recent Improvements in the Luminous Arc Lamp (*Elec. World*, October 3rd).

CONTRACTIONS USED.

G. W.—*Gas World.*

J. G. L.—*Journal of Gas Lighting.*

12

THE JOURNAL OF SCIENTIFIC
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OFFICIAL ORGAN OF THE
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(Founded in London, 1909.)

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EDITORIAL.

Shop-lighting in War Time.

THE full account of the meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts on December 1st, will appear in our next issue. But in view of the obvious interest, at the present moment, of the section of the discussion dealing with shop-lighting, we will anticipate by making a few remarks on this subject.

The object of the meeting was to suggest some conclusions to be drawn from the present lighting conditions in London, and in particular to suggest, if possible, how merchants can best arrange the lighting of their windows so as to comply with the official regulations. Naturally, we are all willing to comply loyally with these requirements for the public safety; the readiness with which the public has fallen in with the somewhat stringent regulations is a striking testimony both to the law-abiding instincts of the community and the forbearance with which the police habitually act.

But the satisfactory arrangement of the lights is a technical problem, and it therefore seemed possible that a discussion among members of the

Society would lead to the framing of some recommendations by which the desired results could be obtained with a minimum inconvenience to the public. Now that the Christmas trading season is drawing near, the benefits of good window lighting must not be lost sight of, and we believe that it should be possible to keep this aim in view and yet not to transgress the official regulations. Some attempts have been made in this direction with highly satisfactory results.

Clearly the first point to be observed is the masking of brilliant lights in and outside the windows. Now, from the very commencement of the Illuminating Engineering Movement we have always contended that the merchant's needs were best served by avoiding glare of this kind and by using concealed lighting ; treating the window like the stage at the theatre, where the illuminated scene is the essential and visible thing, and not the means by which it is illuminated. Originally there were some representatives of prominent stores in London who apparently did not agree with this view, but at the present time the method is practised by most of the leading merchants, and we hope to see it further extended to the smaller shopkeepers.

As regards the present need for a more precise specification, the Illuminating Engineering Society has taken the matter in hand. It is proposed to frame some rules as to the permissible intensity of illumination and arrangement of lamps for shop-window lighting which will be submitted to the authorities for acceptance. We may presume that the expert knowledge of the members of our Society will carry weight, and that their suggestions will be carefully considered.

If the official approval of these arrangements could be gained, merchants who adopted them would have the satisfaction of knowing that they were doing all that was required, and at the same time securing the best lighting arrangements which the present situation makes possible. We have reason to believe that if such a specification were prepared contractors could be found in each district ready to carry it out, in accordance with the recommendations of the Society. This would bring contractor, consumer, and the authorities into agreement, and would do much to diminish the possibility of misunderstandings. It would provide a standard which would be accessible to everyone and applicable to all illuminants, and would no doubt be very useful to the smaller shopkeepers who have no engineers of their own to advise them on lighting, and frequently do not know where to go for guidance.

What we wish to point out is that merchants who have adopted this principle of concealed lighting have already done a good deal to comply with the official regulations, and, with a little modification, the lighting of their windows has invariably been sanctioned. Those lighting contractors who have identified themselves with this method should find their services in demand to-day, and there is little doubt that

after the war is over a great impetus will be given to this system of window lighting. A series of booklets has been issued by some of the leading manufacturers dealing with the subject and dwelling on the importance of scientific methods. We are glad that there are at length signs that the aims of the Illuminating Engineering Society are being adopted in a practical manner, and we hope that those contractors and manufacturers who are thus reaping the benefits of the movement will, in return, show their appreciation by giving it more generous support, and by coming forward and joining the Society in larger numbers.

There is another point that emerges from the discussion, namely, the desirability of some sane and salutary regulations on shop-lighting, even in times of peace. It is clearly a drawback that the shops in a fine street should be lighted without any attempt at uniformity or artistic design. A shop-window lighted in a moderate but really artistic manner may be " killed " by the tasteless display of very powerful and glaring lights next door. By such exhibitions the appearance of a street as a whole suffers. It is recognised that a man has a legal claim against a neighbour who blocks out an undue proportion of the daylight by erecting a building. Why should not a merchant have the same right, when he has devised and used for a considerable time a satisfactory scheme of illumination, to complain of a neighbour who suddenly interferes with his business by installing ugly and barbarous methods of artificial lighting ?

During the last few years architects have frequently used their influence in favour of a more uniform and graceful arrangement of the buildings lining a street. We would like to have associated with this movement a recognition that the lighting is an essential factor in the appearance of a street by night, and we hold that in the chief streets of a metropolis it should be supervised in the same careful manner.

Our present cities, of course, have grown up somewhat chaotically, but it is already recognised that in new areas a more deliberate attempt at town-planning would be desirable. Some day perhaps we may have a Ministry of Fine Arts which will attend to these matters, and we hope that the supervision of the artistic possibilities of lighting will be included in its functions.

Legislation on Lighting Matters.

We have received a summary of the proceedings at a recent meeting of the Council of the Illuminating Engineering Society in the United States, which shows the enterprising manner in which the Society is studying current problems. At this meeting the Report of the Committee on Lighting Legislation was presented. It is stated that a complete *precis* has been prepared of the laws in three States—New York, Pennsylvania, and Connecticut—bearing on this subject. The Committee is also considering the " General Orders " of the Industrial Commission of Wisconsin, which, as we have several times pointed out, has shown itself very active in dealing with industrial lighting.

An important announcement is that " the Legislative Committee acts in an advisory capacity with governmental authorities whenever the enactment or revision of laws pertaining to lighting is concerned." It is also stated that a " Lighting Code " on school lighting and another on factory lighting are now being prepared. These recommendations will be followed with great interest by lighting engineers in this country. No doubt the

committees will bear in mind the work already done here on the same subject, in order that the recommendations in the two countries will be in substantial agreement.

Illumination in the Law Courts.

The access of daylight into many of the existing Law Courts may well be considered insufficient, judging by modern standards. Some of them are in old buildings, erected in days when the relation of window-space to floor area was not studied in the same careful manner as now, and the reliance on documentary evidence, possibly, was not so great as it is to-day. In the case of these old buildings, many of them of great historical interest, it would probably be difficult to make such structural alterations as would alter the access of daylight very considerably. But in the case of new buildings we should learn by past experience and make sure that the natural lighting is thoroughly up to date.

The administration of the law depends materially on the provision of ample illumination. It is probable that the mere fact of cases being tried in a forbidding and gloomy interior has been responsible for an impression of obscurity which should be no part of our legal system. Dickens, in his references to the law, frequently associates the two things. In the United States Juvenile Courts, we understand, cheerful and bright rooms were deliberately selected so that these young offenders should not be needlessly terrified by the majesty of the law, and we think that the average layman would agree that a well-lighted room helps to create the impression that all is fair and above board.

The case for good illumination from the purely technical legal standpoint was well stated by Mr. A. S. Osborn, Examiner of Questioned Documents, in a paper before the recent Convention of the American Illuminating Engineering Society. The interpretation of a witness's evidence rests not only on the spoken word, but on his appearance and expression while giving this evidence. Judge, Counsel, and Jury habitually scrutinise the face of a person under examination.

When we come to documentary evidence the importance of good light is even clearer. The examination of legal documents, the detection of erasions, the judging of handwriting, &c., all require an exceptionally good illumination. No doubt much of this expert work can be done outside the court, where all the refinements of light necessary for these tests can be provided. But it must often be desirable for an expert witness to produce the documents to illustrate his case in court, and Mr. Osborn maintains that in many instances the lighting is insufficient for such a purpose. When to these considerations we add the fact that most of the chief personages in court, as well as the reporters, are constantly engaged in taking notes of the proceedings, the need for ample illumination is fully substantiated.

We have said that in some historic legal buildings architectural considerations make it difficult to secure profuse admission of daylight, and in our uncertain climate it must often be necessary to use artificial light, even in the daytime. Whatever limitations there may be to the natural lighting, there is surely no reason why the *artificial lighting* should not be adequate, and it would be advisable for the Society to take steps to bring this matter to the notice of legal authorities.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(A Report presented by the Committee on Progress at the Eighth Annual Convention of the Illuminating Engineering Society (U.S.A.), at Cleveland, Sept. 21–24, 1914; slightly abbreviated.)

(*Continued from page* 514.)

Electric Incandescent Lamps (*continued*).

Vacuum Tungsten Lamps.—Since the first of the year there has been a 10 per cent. increase in efficiency in the ordinary drawn-wire tungsten lamp[23] both in the multiple type and also in the street railway and train lighting lamps and this has been accompanied by a decrease in price of from 10 per cent. to 15 per cent.[24] There seems to be a steadily increasing tendency on the part of central stations[25] to further the use of the tungsten lamp through free renewals and decreases in prices.

According to the Lamp Committee report[26] the quality of vacuum tungsten lamps has been greatly improved. The filaments have been made stronger; a change has been made from heavy to light semi-flexible or flexible supports; and the introduction of chemicals to prevent blackening has been extended to the lower wattage and been greatly improved in the higher wattage sizes.

A decided improvement in these lamps has been along the lines of standardization and uniformity of the various constituent parts such as bulbs, stems, supports, &c.

Among foreign manufacturers a number of filament mountings have been worked out. One[27] giving a maximum intensity in the lower hemisphere consists of a rectangular glass frame from which the supporting wires hang down, the filament being wound back and forth so as to lie in the same horizontal plane, the lamp being used pendant.

[23] *Cent. Sta.*, March, 1914, p. 354.
[24] *Elec. World*, March 28, 1914, p. 68
[25] *Cent. Sta.*, May, 1914, p. 417.
[26] *Loc. cit.*

[27] *Zeit. f. Bel.*, October 20, 1913, p. 415.

The ability to wind the drawn wire tungsten into spirals of very small diameter has made possible also a variety of methods of mounting.[28] An arrangement giving a result similar to the one just mentioned consists in placing the supporting wires radially in the same horizontal plane and looping the filament between them. Another type[29] uses three vertical glass rod supports with the filament wound spirally around them. Another[30] has the supporting wires in the same plane and forming a four-pointed star. In another lamp[31] the filament is wound in the form of an inverted cone, and the bulb is either clear or has its upper half frosted and the lower half ribbed. One type uses the grid form first mentioned with the spirally wound filament. In still another type in order to get a maximum of length[32] in a minimum of space vertically and thereby permit the use of a small diameter bulb, the spiral wound wire is held by supports which carry it spirally around the central glass supports.

This year has seen the almost complete elimination of the tantalum lamp, the number used being less than 0·1 per cent. of the total number of lamps sold, while the number of carbon lamps used has dropped to only 10 per cent.

The government has revised its standard specifications for incandescent lamps.[33] The new schedule calls for 200—260-volt tungsten lamps, raises efficiency limits and lowers voltage limits. The tantalum schedule has been dropped. In both the tungsten and graphitized carbon schedules the sizes of bulbs are named, indicating the progress in standardizing which permits such designations.

An extension of that method of rating lamps for efficiency,[34] based on the fact that equal efficiency means equal brightness in vacuum incandescent lamps having the same filament material, has been devised. The method is particularly designed for conditions where the testing voltages are fluctuating, and uses either direct or alternating current. The optical pyrometer principle is involved and the apparatus is very simple including a voltmeter and some suitably chosen resistances.

The advent of the high efficiency non-vacuum lamp of high current has necessitated the development of special holders which shall provide ventilation and protection from moisture. In the case of the low-voltage high-current type a compensator for street series lamps has been produced which in some cases effects an appreciable saving in energy.

Various devices have been invented to prevent the unauthorized removal or theft of lamps and reflectors.[35] One of these recently developed is so arranged that a lamp once screwed in cannot be removed without beaking it. Replacement of a lamp is accomplished by breaking the bulb, which allows the slipping off of the outer shell of the socket, and permits the unscrewing of the discarded base.

Difficulties in the manufacturing of carbon lamps in the early days[36] are partly responsible for the wide range of voltages in the distributing systems of central stations. But the recent great improvement in the manufacturing processes connected with tungsten lamps has enabled the factory to produce lamps of a given desired voltage to within very narrow limits. It has been suggested that if it were feasible to have central stations adopt a standard voltage, it might be possible to still further reduce the price of lamps by relieving the manufacturer of the necessity of providing for more than one voltage.

Efforts are being made at the present time to have central stations bring their voltage as nearly as possible to the 120-volt center.

Arc Lamps.

The result of considerable research has brought out an improved electrode for the magnetite arc.[37] This, together with a prismatic refractor which redirects light

[28] *Elek. Anz.*, October 5, 1913, p. 1128.
[29] *Elek. Zeit.*, September 25, 1913, p. 1122.
[30] *Elek. Zeit.*, November 27, 1913, p. 1381.
[31] *Elek. Times*, February 5, 1914, p. 152.
[32] *Zeit. f. Bel.*, June 20, 1914, p. 221.
[33] *Bur. of Std.*, Circular No. 13, 1914.
[34] *Light Jour.* (U.S.), November, 1913, p. 272.
[35] *Elec. Rev. & W.E.*, December 6, 1913, p. 1130.
[36] *Elec. Rev. & W.E.*, August 1, 1914, p. 202
[37] *Gen. Elec. Rev.*, March, 1914, p. 292.

formerly lost, has made a big advance in the mean hemispherical efficiency of this type of arc lamp.

Improvements have been made also in the flaming carbon arc lights. A new type has been developed in which the lamp forms the top of a pillar and which combines the operating characteristics of the long burning arc with the ornamental design inherent in the adoption of the classic column. Research has shown that good operating results may be secured by the use of a small condenser having vertical, concentric sides.

In response to the demand for ornamental units, the appearance and diffusion of arc lamp globes have received some attention with beneficial results.

In enclosed flaming arc lamps[38] the effects of water in the enclosing globes has been studied recently. It was found that one effect is to lower the temperature of the arc due to the formation of hydrogen which rapidly conducts heat away from the electrodes. It was found also that there is a remarkable shortening in the life of the trim if moisture is present in the globe.

Vapor and Vacuum Tube Lamps.

Mercury-vapor lamps in general, function on direct current. Those designed for and used on alternating current are arranged so that the final result is an unindirectional action. A new type of quartz mercury arc has been devised[39] having only two electrodes, between which the current alternates. This is made possible at ordinary frequencies (50 volts) by using voltages not less than 600; a pressure not less than of the order of 1 cm. of mercury; the presence of self-induction in the circuit; and when starting having the electrodes already hot. A lamp of this type has been designed for 1,000 volts at the terminals, 1,000 watts consumption, a power factor of 0·7 and a candle-power of approximately 5,000 giving a candles per watt factor of 5.

Another new arrangement of the quartz mercury arc[40] has for its object the production of a light source comparable in intensity with the carbon arc but with the objectionable heating removed. This is accomplished by making the lamp in the form of an inverted U and placing it in a flask one of whose walls is in the form of a paraboloid which may be silvered, and thus concentrate the light emitted through the opposite wall. The flask is made of pure transparent quartz and uses electrodes of invar metal. The whole is then immersed in a vessel either of glass or with glass sides, filled with water. One of the sides may be made in the form of a condensing lens. A lamp so constructed used 18 ampères with 70 volts at the terminals, and was claimed to give 3,000 candle-power or about 0·42 w.p.c. Such a source would have its principal application in cinematography or photomicography.

In cases where the tilting method of starting mercury-vapor lamps is not feasible, a new starting arrangement has been devised,[41] which uses a small auxiliary vessel containing a re-entrant portion in which a heating coil may be placed without disturbing the vacuum. This small vessel is placed immediately below a part of the tube which is near the negative electrode and constricted. Initially the positive and negative electrodes are connected by a thread of mercury which is broken by a bubble of vapor arising and being caught in the restricted portion when the heating coil is started. The operation may be made quite automatic.

Neon.—Work is still being done on the study of the properties of the neon lamp.[42] It has been found that, the current being kept constant, the drop in potential along the tube is approximately inversely proportional to the diameter, the tube operating under a pressure of about 2 mm. of mercury and a current density of 6 ampères per square decimeter. The effect upon the luminous power of varying the diameter has also been studied and it has been found that the luminous power increases approximately as the first power of the diameter. Owing to the loss of power at the electrodes, however, tubes of a diameter about 1 to 3 cm. are best if efficiency is to be considered.

[38] *Elec. World*, December 13, 1913, p. 1220.
[39] *Bul. Soc. Int. des Elec.*, April, 1914, p. 385.
[40] *C.R.*, November, 17, 1913, p. 921.
[41] *Elec. Rev. & W.E.*, October 11, 1913, p. 733.
[42] *C.R.*, February 16, 1914, p. 479.

In England the neon tube has been put on the market for advertising purposes[43] in a standard length of 6 m. a diameter of 50 mm. and using 1 ampère with 1,000 volts at the electrodes.

Cathode Lamp.—A new vacuum lamp has made its appearance[44] based on the fact that the cathode in a vacuum tube becomes very hot on the passing of a discharge. The inventor utilizes this phenomenon to bring to a glow a piece of Nernst heater used as a cathode and contained in a quartz tube, sealed by means of magnesia and pipe clay into a spherical glass bulb.

The claim is made that with 820 volts and 0·11 ampere, or 90 watts, the lamp burns as brightly as a 50 candle-power lamp. Further study is to be made on this lamp.

Ultra-violet Sources.—For some time quartz mercury-vapor lamps, heavily loaded, have furnished the only intense source of ultra-violet radiation in practise.[45] A method has been recently devised which considerably increases the effectiveness of such lamps by using a magnetic field and water cooling. This has the effect of reducing the density and consequent absorption of the vapor envelope, and shifts to the side of the tube the concentrated beam of light which ordinarily occupies the center of the tube.

Deduced from photographic action the improved lamp shows the greatest intensity in the region $\lambda = 0{\cdot}254\ \mu$. A further interesting result is that using this lamp to excite a "resonance" mercury-vapor lamp (a quartz glass absorption vessel provided with a drop of mercury, exhausted and sealed) the extremely mono-chromatic radiation of wave-length $\lambda = 0{\cdot}2536\ \mu$ may be produced continuously and with considerable intensity.

A study of the oscillating spark between various metal electrodes[46] as a source of ultra-violet radiation has shown a maximum intensity when using invar, the value being almost twice that obtained with copper.

[43] *Elec. Eng.*, (London), March 5, 1914, p. 138.
[44] *Elek. Zeit.*, March 5, 1914, p. 259.
[45] *Elec.*, April 3, 1914, p. 1074.
[46] *C.R.*, May 11, 1914, p. 1337.

Light Sources for Projecting Purposes.

Headlights.—The enormous increase in the use of automobiles both for pleasure and traffic has made the question of proper headlights of steadily increasing importance. In the larger cities particularly legislation to prevent the use of dazzling headlights has been put into effect. One result has been the development of numerous schemes to shut off the excess of light while in the city, but leave the full intensity available for use on unlighted roads.

Instead of using four headlights,[47] two of high power for country touring and two of low power for city driving, one arrangement provides twelve lights placed along the filler board between the windshield and the top of the engine hood. When not in use the lamps are completely covered by a sliding shutter which may be moved to permit the use of as many as desired and of particular ones if necessary. Furthermore the angle of the group of lamps can be varied at the will of the driver, so as to illuminate any portion of the road, or the engine of the machine.

In another system,[48] two lamps are used, having a tubular body, fitted with a system of lenses and a reflecting mirror, the result being a concentrated beam projected in nearly parallel rays, and capable of easy direction.

Another form[49] has two pairs of translucent wings mounted on pivots and made to open and close by electromagnets controlled by a push button on the dash.

The National Physical Laboratory has had the subject under advisement for some time[50] and recommends the cutting off of the light beams coming from the upper right hand corners. The right hand corner is indicated because in England the rule of the road is to the left.

In regard to locomotive headlights[51] a similar state of interest is evident, but the crying need for definite information as to the actual needs in this direction is evidenced by the fact that in this country twenty-eight states have adopted legislation embodying seventeen different

[47] *Sci. Amer.*, June 20, 1914, p. 497.
[48] *Sci. Amer.*, March 14, 1914, p. 233.
[49] *Sci. Amer.*, March 7, 1914, p. 204.
[50] *Elec.*, July 10, 1914, p. 574.
[51] *Rlwy. Elec. Eng.*, March, 1914, p. 349.

specific laws governing the use of such headlights.

Searchlights.—A big advance in searchlight construction[52] is shown in a new type which has small electrodes, operates at a high current density and temperature, and has an improved specific consumption. The current density is about six times that of earlier types of lamps. This is accomplished by forcing alcohol vapor around the electrodes to act as a cooling medium and protect the electrodes from too rapid combustion.

The positive crater appears like a sharply defined point of light of extremely high specific intensity. The feeding of the alcohol vapor takes place automatically when the arc is struck, a valve governed electromagnetically being used for this purpose. Both electrodes are rotated uniformly in order to maintain perfectly uniform bathing of gas, and are placed the one horizontal the other at a certain angle to insure equal combustion.

Signal Lights.—A striking departure from former methods[53] of railway signaling is forecasted in the results of tests made to determine the right intensity of a signal lamp so that it will be clearly visible in bright sunlight and not too dazzling at night. If practical experience proves the system to be as effective as the preliminary tests indicate, the old semaphore arm method of daylight signaling will become obsolete in cases such as electric roads where energy is cheap.

The method of momentarily obtaining high intensity by using a tungsten lamp at voltages much above normal has been utilised in a signaling device for soldiers and airmen.[54] It consists merely of a minute incandescent lamp in conjunction with a parabolic mirror and arranged so that the circuit can be closed intermittently to give long or short flashes, corresponding to the dots and dashes of the Morse code.

Another advance in the use of lamps for signaling is in connection with city traffic. A scheme is being tried out in Cleveland of directing traffic at busy street intersections by red and green lamps placed on cross arms on 15-ft. (4·57 m.) poles at each of the four corners. Control is vested in the traffic policeman who is in a booth at one of the corners.

An improvement on the reflecting portion of the light source of light-houses[55] uses a mirror composed of elements both parabolic and annular combined with a spherical mirror. The former project the rays emitted from the front of the lamp and the latter those from the rear.

Miner's Lamps.

The past year has seen a remarkable development in safety lamps for use in mines. Over a year ago in a competition held in England 195 different portable lamps were submitted and of these a number were accepted. Recently the British Home Office has approved of several new types.[56]

As the result of a prize competition in Germany,[57] a lamp has been evolved which is not only safe if broken but is also claimed to give indication of the presence of fire-damp. The principle on which the indicator is constructed is based upon the law of diffusive action. The indicator consists of a U tube containing a coloured signaling fluid and so disposed that the presence of gas causes an obscuration of the light.

However, objections have been raised to this form of indicator based on the fact that it would not be operated upon by an explosive gas mixture, if this mixture were of the same density as the air.

In this country developments have proceeded along two lines, lamps designed for mines where fire-damp or other explosive gases are encountered, and those designed for mines such as metal ore mines where these difficulties are not encountered. Three out of six lamps sent to the Bureau of Mines for test[58] were accepted for use in gaseous localities. These were of both the hand and cap

[52] *Elec. World*, July 25, 1914, p. 181.
[53] *Rlwy. Elec. Eng.*, May, 1914, p. 395.
[54] *Sci. Amer.*, July, 1914, p. 30.
[55] *C.R.*, March 30, 1914, p. 394.
[56] *Elec. Eng.* (London), May 7, 1914, p. 253.
[57] *Elec. Times*, May 7, 1914, p. 509; May 14, 1914, p. 536.
[58] *Elec. World*, December 6, 1914, p. 1165.

service type. The following specifications have been issued by the Bureau :—

Intensity of light at all times..	0·4 c.p.
Flux of light at all times	
Hand lamps	3 lumens
Cap lamps	1·5 lumens
Time of burning per charge ..	12 hours
Average life of bulb	300 hours
(Not more than 5 per cent. to have less than 250 hours.)	
Average life of batteries ..	3,600 hours
Variation in energy consumption of bulbs	10 per cent.
Angle of reflector	100 degrees

Acetylene.—For mines where the question of fire-damp and explosive gases does not have to be considered[59] the use of acetylene has been growing. Until recently the acetylene lamp has been developed for eastern mining conditions and has been of the hat or hand type. But in timbered mines the hat lamp is not used and recently an acetylene lamp has been brought out mounted in a hafted holder, so that the lamp can be positioned by sticking the haft into the timber or soft ground.

In this connection an effort is being made[60] to obtain an acetylene lamp for use in gaseous mines, and in Geneva, Switzerland, under the auspices of the acetylene associations of various countries a prize of $1,000 has been offered for a safety lamp that fulfils all requirements, both as to gas protection and technical and economical working.

(To be continued.)

[59] *Acet. Jour.*, April, 1914, p. 409.

[60] *Acet. Jour.*, May, 1914, p. 425.

GLASSES TO ABSORB INJURIOUS RADIATION.

A RECENT communication to the Royal Society by Sir William Crookes describes a most elaborate series of tests on glasses with a view to discovering varieties which will cut off excess of heat rays and ultra-violet energy.

The difficulty has been to get glasses which would absorb this injurious radiation without blocking the visible rays or colouring the light too much. Some of the glasses described seem to be quite remarkably successful in this respect. For example, some varieties transmit 70—95 per cent. of visible light but are opaque to ultra-violet rays, while others cut off as much as 98 per cent. of the radiant heat.

The table comprises a series of glasses which is regarded as combining these good qualities and having a general utility :—

Glass No.	Absorption of heat.	Absorption limit in ultra-violet.	Transmission of light.	Colour.
	per cent.		per cent.	
249	51	3550 $\mu\mu$	63	Pale blue
197	41	3800	45	Pale neutral
252	47	3680	45	Faint blue-green
165	38	3680	42	Pale yellow-green
210	87	3620	30	Blue-green
248	47	3550	30	Dark neutral

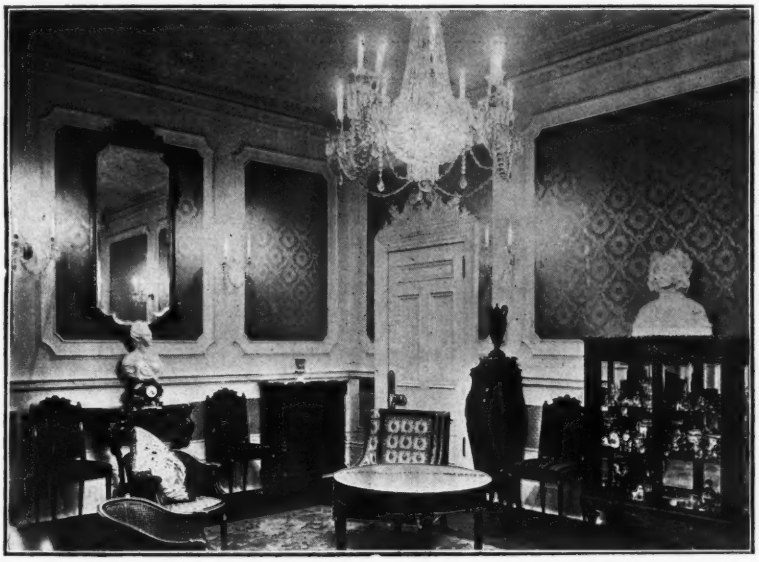
CHANDELIER-LIGHTING IN A DRAWING ROOM.

In a recent issue* we published a series of simple recommendations on domestic lighting, dealing with the problems mainly from the practical and "utilitarian" aspect.

But it must be remembered that there are other conditions that guide the consumer. In many instances the style of the room demands a certain type of fitting. The art of the fixture designer is employed to harmonise the lighting and the scheme of decoration, and the more strictly "engineering" aspects of the problem sink into the background.

At the same time we may be sure that lighting conditions that are really pleasing to a person with artistic discernment will also conform with fundamental requirements as regards avoidance of glare; the amount of illumination provided naturally depends on the use to which a room is put as well as its architectural features.

In the illustration we have a drawing room in the French style. There is a central cut glass chandelier, and on the walls, brackets with imitation candles. Attention may be drawn to the pleasing silk panel wall decorations. These fittings, while possibly open to objection from a purely engineering standpoint would probably be considered to meet the artistic requirements of the room—they are what the general style of the interior demands.



Lumina Bureau Photo.

It must, of course, be remembered that a room of this kind is not intended for reading and writing but for conversation, &c., and therefore a very strong light is not needed.

At the same time the effect, although bright, is not glaring, and it is worth noting that the candles and chandelier have a white background which both reduces the "contrast effect" of their brightness and helps to diffuse the illumination in the room.

* *Illum. Eng.*, London, Oct., 1914.

ILLUMINATION IN THE LAW COURTS.*

The Value of Light in Examining Witnesses and for the Inspection of Legal Documents.

By A. S. OSBORN.

AN enterprising step was taken by the American Illuminating Engineering Society at their recent Convention in asking Mr. A. S. Osborn (Examiner of Questioned Documents) to discuss the use of light in the law courts and in connection with legal documents.

From a general standpoint the illumination in the courts should obviously be ample, so as to enable judge and jury to see witnesses with the utmost distinctness while they are giving evidence. Few people realise how greatly they are guided by the ear in estimating what is said. The impression conveyed by a sentence may be entirely altered by the tone of the voice. But even fewer people, probably, realise that the meaning of spoken words is also dependent, to a great extent, on the expression of the face; and that the bearing of a witness under examination may be as significant as his actual admissions.

Clearly, therefore, there should be good lighting, so that the face of a witness can be clearly seen. Yet the illumination is rarely attended to as well as it should be. "A visit to many a court room," Mr. Osborn remarks, "is sufficient to show that how such a room should not be arranged and should not be lighted. Artistic and architectural considerations, in many cases, would seem to be the only ones that had been consulted in the arrangement. In many a city of our land, of all places, the court room is the one place where it is most difficult to see, and the administration of the law could be greatly aided by the lighting engineer, the ventilating engineer and the acoustic engineer. There are many court rooms so dimly lighted and so improperly arranged that it is almost impossible in them to prove forgery when such proof must be based upon the correct interpretation of delicate but significant evidence. In some few cases court and jury leave their accustomed places and in an informal and sensible manner gather round some low-placed, clean window where all can see and all can hear. . . . Many a city in this land has spent millions of dollars on a court house without one properly lighted and well-arranged court room where clear seeing and distinct hearing are possible. . . . The modern laws of some states happily require a certain amount of properly placed light in every school house, but such laws, it would seem, have not yet been applied to the law houses."

Besides the general requirement of being able to see the faces of people in court the inspection of legal documents really calls for local illumination of a high order. Both the microscope and the camera often reveal details which have an important bearing on the result of will cases, &c. A photographic enlargement will often show where writing has been touched up in a forgery. The varying thicknesses of the ink film, and the difference between old and newly inscribed ink are revealed by their difference in ability to transmit light. Again, there are certain kinds of erasions, such as particularly the removal of pencils lines, which would not be revealed by ordinary illumination and might escape detection even under the microscope; but they are revealed when the paper is illuminated by very oblique light. Sometimes the shadow cast by these shallow impressions actually enables the expert to see what was written, even though the words may be totally invisible by any ordinary method of examination.

The tintometer is sometimes requisitioned in order to detect those portions of a document that have been added. It sometimes happens that the newer ink has not quite the same tint as the older writing, and the two are differently matched in a delicate test for colour.

Finally there is the application of photography by ultra-violet light, through which, it is said, stains or abrasions which are totally invisible by ordinary light are readily detected.

* Paper presented at the Eighth Annual Conference of the Illum. Eng. Soc. (U.S.A.), Sept., 1914.

THE EIGHTH ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

(HELD IN CLEVELAND, OHIO, SEPTEMBER 21ST–24TH, 1914.)

THE Convention of the Illuminating Engineering Society in the United States appears to have been a very successful one, nearly 300 members being present. In what follows we give a summary of some of the papers.

As promised in our last number, we are also reproducing several views showing various features of interest at Nela Park, which was visited in the course of the Convention.

ARTIFICIAL DAYLIGHT.

In a paper by Messrs. M. Luckiesh and F. E. Cady on this subject fairly familiar ground was covered. The most novel point was the use of special screens to produce artificial daylight with the new Half-Watt lamps. It was stated that with tungsten lamps of the ordinary kind accurate screens would only transmit about 14—18 per cent. of light, but with the Half-Watt lamp 25–33 per cent., nearly double the transmission, is possible. A Half-Watt lamp thus corrected to give an exact resemblance to daylight would have to work at about 10 watts per candle.

In the discussion Mr. D. H. Stickney pointed out the distinction in the following classes of work:—*Textile mills*, where a high degree of accuracy is demanded and efficiency is a secondary condition; *other industries*, where lesser accuracy is needed but greater efficiency is desirable, and stores, where slight variations in tint will not be objectionable.

A paper was also read by Mr. E. J. Brady on the development of daylight glass. It is difficult to find colouring materials which will dissolve in the glass and yet will not deteriorate with age or temperature. Black oxide of copper, cobalt oxide, and black oxide of nickel were used.

It would appear that the light obtained by the use of this glass resembles closely that obtained from a black body heated to 5,000° absolute.

Among other points raised in discussion, Mr. C. O. Bond suggested that a large installation of artificial daylight screens should be made, and should be given an actual practical working test, lasting twelve months or more. Mr. Macbeth spoke of the difficulty of matching fabrics under artificial illumination, and said that a designer of women's dresses often finds it difficult to select colours which will harmonise under artificial lighting as well as under daylight. One tailor in New York City, he declared, had brought out a line of blue dress suits which appear black under artificial light instead of showing the rusty brown so often taken by ordinary black broadcloth material.

DAYLIGHT AND SUNLIGHT IN BUILDINGS.

A paper by Messrs. L. B. Marks and J. E. Woodwell, entitled "Planning for Sunlight and Daylight in Buildings," was one of the most informing read for the congress. The authors quoted Dr. S. A. Knopf, in a recent statement submitted to the Heights of Buildings Commission, New York City, as follows:—

> "Tuberculosis, which is propagated by bad air, foul air, and lack of sunlight, causes annually a loss of 200,000 citizens to the United States. The disease could be largely prevented would we live and work in pure air, in air relatively free from mineral and vegetable dust, and last, but not least, would we construct the buildings in which we live and labour so to allow sunlight to enter more freely."

At a recent meeting of the Municipal Art Society, a prominent speaker said:—

> "I read in my newspaper to-day of the benevolent project to build a great hospital for consumptives, the victims of tuberculosis, where they may have air and sunlight. And in the same paper I read of plans for a 30-storey building. What are we trying to do? What do we mean by putting up these horrible structures, to the lower floors of which no light can ever penetrate? We build hospitals for the poor

consumptive, and then we turn round and erect sky-scraping structures where consumption may breed, so that we shall not have a lack of patients.

The authors also give a table summarising the regulations as regards Heights of Buildings and Street Width in various American cities. For example, in Chicago, the height of tenements is limited to 1½ times the street width, and the height of their buildings is 200 feet. In many cases the regulations are equivalent to prescribing a minimum angle of light of 45°.

In the remaining portion of the paper the authors give methods of testing daylight conditions, and present some interesting figures obtained by actual tests on the site of the new Court House in New York, previous to the erection of the building. The paper is concluded by a useful bibliography in which reference is made to recent papers before the Illuminating Engineering Society of London.

Amongst other papers we note that by Mr. G. M. J. Mackay on Half-watt lamps, in the course of which he states that the evaporation of tungsten at the pressure of 1000 millimetres of mercury is only about 1 per cent. of that in a vacuum. This helps to explain how it is possible to run these lamps at such a high efficiency.

Lighting through Ceilings of Translucent Glass.

A paper on this subject was read by Mr. E. J. Evans, who rightly pointed out the absence of data on installations using diffusing glass ceilings. In each case the efficiency depends on the extent to which the glass diffuses the light, and the distance between the lighting units depends very materially on this factor.

In the course of the discussion on this paper it was pointed out that ceilings of opal glass appear flat and monotonous, crystal glass gives a more alternative effect, and amber-tinted glass is also useful. Mr. A. J. Sweet described a variety which diffuses the light sufficiently to give no "spottyness" and yet transmits 54 per cent. of light.

Measurement of Transmission and Reflection Coefficients.

A photometer for the measurement and reflection coefficients was described by P. G. Nutting and L. A. Jones. The former also read a paper discussing methods of distinguishing and measuring specular and diffused reflection.

Reference is made to the value of methods making use of polarised light on the lines suggested by Professor Ingersoll in his "glarimeter." An interesting point also discussed at the Convention was the preparation of a material having a standard reflecting value. Substances tested included compounds of calcium, aluminium, magnesium, and boron.

The effect of the size of the grains of material was considered, and it was found that extremely fine powdered crystals gave the best results. Magnesia, when specially heated, gave the highest reflecting power of the materials tried, namely, 88·1 per cent., but on exposure to the air the coefficient gradually fell to 85·3 per cent.

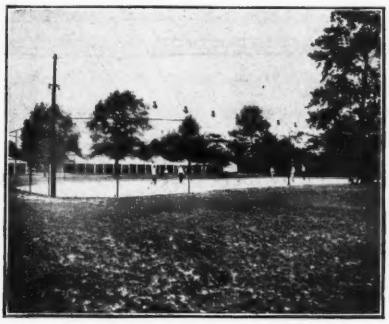
Light in the Treatment of Disease.

We may next notice a paper by Mr. H. H. Clark on portable Electric Lamps for Mines. Dr. E. C. Titus dealt with the use of electric light in the treatment of disease. He made an interesting statement that the thermal effect of light penetrated 2 inches or more below the skin. Nowadays 500-candle power incandescent lamps with suitable reflectors can be used in place of arc lamps. Light is used in the form of baths for hardening the arteries and for treating rheumatism. The arc light sources can be used for destroying germs and promoting the growth of a healthy tissue.

Tests for Eye Fatigue.

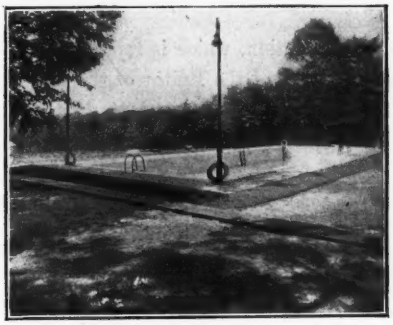
Some experiments on this subject were undertaken by J. R. Cravath in conjunction with Professor C. E. Ferree. One of the methods employed is for the observer to gaze steadily at a card upon which certain letters are printed, and to notice the period of time before which the letters become slightly blurred. It appears that this method is sensitive both to fatigue of the eye and to abnormal conditions due to headache, irritation due to the dust of the eye, &c. There was also a distinctly elaborate paper by Dr. Ferree and Mr. G. Rand, summarising a continuation of the researches described

A Lecture being given in the Outdoor Auditorium.



Artificially illuminated Lawn Tennis Court.

A view of the Girls' Club House. (Note the semi-indirect lighting units.)



Outdoor Swimming Pool (70 ft. by 30 ft.). Artificially illuminated at night.

SOME FEATURES OF INTEREST AT NELA PARK, CLEVELAND, OHIO.

at the previous Convention. The effect on the eye of varying the area of the illuminated ceiling and of using opaque eye shades, and also of moving pictures on the eye and different distances, were also discussed. In the discussion the interesting statement was made by Dr. D. M. Moore that acuteness of vision varies cyclicly with the heart pulsations and the supply of the blood to the retina. Tests appear to have shown more fatigue by direct lighting than by indirect. Professor Caldwell pointed out that it is very necessary to distinguish between mental strain and fatigue of the eye.

P. S. Nutting presented some further mathematical data on the visibility of radiation, and Dr. H. M. Johnson described some tests on the vision of various animals. He stated that the monkey appeared to have acuteness of vision of about the same standard as that of a man, while that vision of the chicken is only 20—25 per cent. as good.

Finally, there are several papers on photometry. Mr. L. A. Jones described some experiments on the acetylene flame as a light standard. Messrs. N. K. Chaney and E. L. Clark entered somewhat elaborately into the theory of the integrating photometer. The error introduced by the position of the screen used with the light source, and by variation in the distribution of light from the lamp studied, were discussed. The use of translucent screens was not found desirable and it was considered that modern extensive sources can be tested with quite sufficient accuracy.

SHORT NOTES ON ILLUMINATING ENGINEERING.

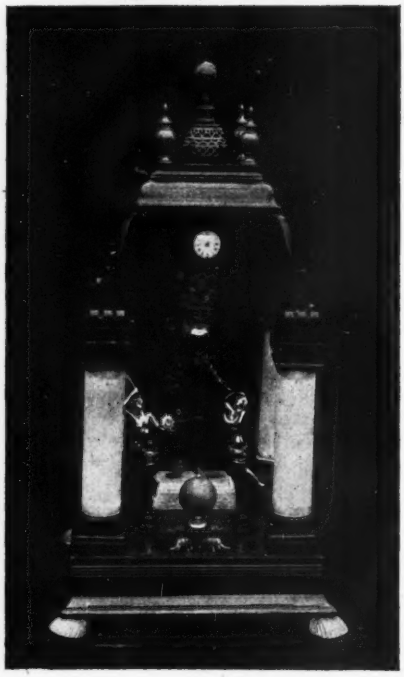
A CURIOUS TIMEPIECE.

THE illustration, which is reproduced by the courtesy of the Editor of the *City of Birmingham Gas Department Magazine*, shows a curious and interesting clock designed by Mr. Steventon, of the Mantle Maintenance Department.

The scheme of design is "Time with Night and Day over the World. After describing the general structure of the timepiece the article continues:—"The large figure at the back is standing on a white marble plinth, carved on front and sides with floating swans, and inlaid on top with ebony stars. The small figures are of brass on black ebony plinths, the one holding the Sun and a flaming torch, and the other the Moon and a Star.

"The Sun is made from burnished copper and set with a topaz, whilst the Moon and Star are made from silver set with white stones. It will be noticed that Night is shading her eyes from the Sun's glare. The World (once an ivory billiard ball) is supported on a supported silver plinth held on the backs of four elephants. The watch is a Verge and is about 200 years old."

We may add that the issue of the *City of Birmingham Gas Department Magazine*, from which this illustration is taken (November, 1914), is an exceptionally interesting one, and contains letters from many members of the staff who have become members of Lord Kitchener's Army.



A curious Timepiece symbolising "Time with Night and Day over the World."

IN DARKEST LONDON.

A NUMBER of articles are appearing as to the wisdom or otherwise of the present arrangements for artificial lighting in the Metropolis and other important cities; a peculiarity about the matter which has not attracted attention is that the whole responsibility for regulating the lighting rests with the police, and thus very largely with individual constables who patrol the streets. Now the question arising as to sufficiency or insufficiency of illumination, glare, or its antithesis, are not simple matters which can be mastered in a day (or a night) by a layman whose educational qualifications are not his strong point; we have seen constables drilling in the early days of their career, we have read of constables who have been complimented by experienced K.C.'s on the rapid way in which they decide to act or not to act on the spur of the moment where some abstract reading of the law is the determining factor; but we can hardly imagine that any members of the force have studied the subject of artificial illumination—suddenly thrust upon them—in sufficient detail to ensure election to, say, the Illuminating Engineering Society. Moreover, individual constables are not granted the use of discretion, and therefore they attempt to apply, as far as their intelligence enables them to do, the interpretation of the Commissioner's orders to all parts of the Metropolitan Police area—from Potter's Bar to Purley, and from Staines to Gravesend—regardless of circumstances, regardless of weather conditions, regardless of the citizens' comforts and prejudices.

Perhaps a more co-ordinate system might be arrived at if the Chief Commissioner had at his disposal the assistance of some men with knowledge of the Metropolis and of the subject being dealt with. No doubt abundant assistance would be forthcoming if an application were made through the learned societies, or a batch of special constables enrolled to deal with the problem under a more carefully planned scheme, drawn up under favourable conditions, than it can have been possible for the police to work out under the pressure of their ordinary duties.

We are by no means inclined to belittle the importance of the matter—rather we consider it far too important a matter for the police (unaided) to handle. A Zeppelin load of explosives (say about two tons) distributed over London would quickly convince the people of London that there are inconveniences even greater than those caused by subdued artificial illumination.—*Electrical Review*, November 6th, 1914.

CONSUMPTION OF INCANDESCENT MANTLES IN FRANCE.

ACCORDING to the *Science et Art de l'Eclairage* (June, 1914), the total consumption of incandescent mantles in the world approaches 300,000,000, of which approximately 50,000,000 are used in France. Of this number France produces approximately a half. The war has doubtless had already a most disturbing influence on this industry. France, like us, can obtain no mantles from Germany, and is apparently unequal to maintaining her own consumption even in normal times.

THE LIGHTING OF BARRACKS.

WE have had occasion to look into the regulations governing the lighting of military barracks—and in this category are included the huts now being erected for the new army. The method of determining the amount of light to be provided, it must be admitted, is somewhat antiquated. No consideration is apparently given to the particular operations being conducted in any particular position, a general figure of 1 candle-power per 13 or 14 superficial feet of floor space covering all cases.

It would thus appear that whether it be a corridor, or a room in which reading or writing may be indulged in, the amount of illumination is to be that same. This is a somewhat absurd proposition, and coupled with the low standard of illumination, shows that the regulations are in need of revision.

It will further be noticed that lamps or burners of low efficiency have an advantage over those of high efficiency, for it is well-nigh impossible with the former to keep within the limits prescribed. Imagine the comfort of a room, 20 feet by 20 feet, lighted with a 28- or 30-candle-power light. What should be done, and what anyone outside a Government department would do, would be to prescribe a certain degree of illumination for each distinct portion of the building or hut, and in each case see that it is adequate. Rather than leave matters of this kind in the hands of persons without knowledge of the subject, it would be better to call in one or more expert illuminating engineers to frame a suitable scheme. Men who are giving themselves to be trained for fighting the country's battles are surely entitled to some consideration, and we contend that an evening spent in a room lighted on the War Office scale would be sufficient to damp the spirits of the most enthusiastic. Lighting is very cheap, and we as a nation are not yet financially embarrassed, hence we hope that the authorities will give this matter a little attention.—*Sanitary Record*, November 13th, 1914.

NEW USES OF ELECTRICITY.

IN a recent lecture at the Willesden Polytechnic, entitled "Some Applications of Electric Power and Lighting," Mr. Frederic H. Taylor said that at the present time, motors to the extent of more than a million horse-power are connected to the various electric supply concerns.

Mr. Taylor mentioned some interesting examples on the use of electric power. In the transport of goods electric transporters have now replaced the old-fashioned hand propelled wheelbarrow. Electric lifting magnets shifting huge masses of iron, electric hoists are used for raising the corpses in a crematorium. Great interest had recently been excited by the application of electric light to luminous airship signals, which have been developed very successfully in Germany. At the present time electricity is playing an important rôle in connection with searchlights.

PUBLIC LIGHTING IN VIENNA.

ACCORDING to the *Gas World* the public lighting in Vienna, Budapest and other cities in Austria-Hungary is being much diminished owing to the limitation of the production from the gas and electricity works during the war. This is due to the reduction of coal supplies and the stoppage of production of the oilfields in North Galicia.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

SHOP LIGHTING IN TIME OF WAR.

AT the present moment, when somewhat strict regulations for the lighting of London have been made with a view to taking precautions against possible hostile aircraft, the lighting of shop windows in particular is being discussed. During the present struggle between nations the preservation of our home trade is a most vital matter. Now that the Christmas trade is beginning it is a duty to buy reasonably and as liberally as one's finances allow. A well-lighted window is one of the best methods of proclaiming "business as usual," and by taking expert advice there is no reason why windows should not be lighted in such a way as to comply with the official regulations and yet show off the contents of the window to advantage. The existing regulations insist that brilliant lights in the window are to be screened from view—in this respect coinciding with the requirements of illuminating engineering. It is well known that some companies have made a speciality of this system. For example, a great variety of installations has been described in *Holophane Illumination* (the booklet issued by HOLOPHANE LTD.) during the last few years. We are taking the opportunity to illustrate a few of the most interesting installations.

Merchants should, therefore, appreciate the methods of those companies who have made a study of scientific window lighting and can supply fittings specially designed to screen the light from the eyes of the passers-by, and to concentrate the illumination on the goods in the window.

We have also before us two attractive booklets issued respectively by the BRITISH THOMSON-HOUSTON CO., LTD., and THE GENERAL ELECTRIC CO., LTD., dealing with this subject. In both cases there is a clear recognition of the great benefit of scientific shop lighting, and of the principles which the Illuminating Engineering Society has been bringing before the public.

It is not so very long since the system of lighting windows by concealed lights, on the same principle as on the stage, was not fully appreciated by merchants in London. But with the coming of more powerful illuminants and proper forms of reflectors for concentrating light the method began to find favour. And during the last few years the principles advocated at meetings of the Illuminating Engineering Society have become so widely known that practically all the leading stores in London regard this as the correct method of window-lighting.

A glance at the examples following will give an idea of the variety of methods employed—all, however, having as their principal aim the softening and screening of the lights, and the effective illumination of the goods on show.

HOLOPHANE GLASSWARE FOR SHOP-LIGHTING.

IT has been pointed out that the present official regulations for the lighting of show-windows are essentially framed to comply with the motto "Light on the Object, not in the Eye." This principle has long been advocated by Holophane Ltd. and occurs again and again in the literature on lighting issued by this company. The essential object in all good lighting is to show up the thing illuminated; but in addition, if suitable glassware is used, the lighting unit itself can be made a pleasing object.

We have before us a series of photographs of typical Holophane installations in well-known stores both in London and the provinces; on the opposite page we reproduce a few typical examples.

The first two illustrations are selected to show usual methods of interior store lighting. In these times window-lighting has to be arranged with some care. Even methods of lighting which under normal conditions would be considered quite good practice may require some modification to comply with the official regulations. But the fact that the brilliancy of lighting in such cases sometimes requires reduction only makes it more important to see that the interior of the shop is well lighted. The nature of the glassware and the positions of the units have to be carefully studied in order to give economical as well as pleasing results.

It is well known that the Holophane System of Illumination was worked out in a particularly careful and scientific manner to meet these requirements. There is available a host of different types glassware to satisfy each problem. Thus of the two interior views shown, one represents a furniture store lighted by Holophane Reflector Bowls, the other a Motor Car Show room lighted by Holophane Spheres, the appropriate spacing being used in each case.

In the third illustration we see a window in which focusing reflectors, spaced round the top of the window, are used. The effect of this arrangement is to direct as much as possible of the available light downwards. The actual lights are kept out of the field of view and it would be quite easy to conceal them completely without prejudicing in any way the illumination of the window.

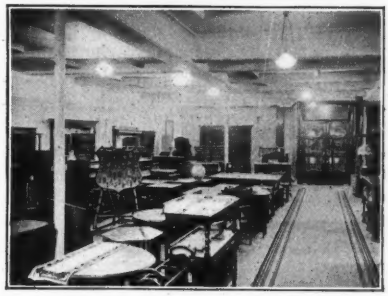
They comply in fact with the requirement "Light on the Object, not in the Eye"—a precept which, as stated above, ought to be widely adopted at the present moment.

MODERN ELECTRIC LIGHTING WITH HOLOPHANE GLASSWARE.

WE have also received a booklet from Holophane Ltd., dealing with glassware for electric lighting.

Besides illustrating the chief types now available, the booklet contains an introduction explaining the basis of the Holophane System of Illumination, and giving a considerable amount of useful engineering data. The chief photometric quantities are defined, and tables of foot-candle intensities for various purposes, intrinsic brilliancy, &c., are given.

In a Furniture Showroom good lighting is an important asset—not only in displaying the goods but in preventing spoilage. Things which are not properly illuminated soon become spoiled and are not carefully looked after, as they should be.

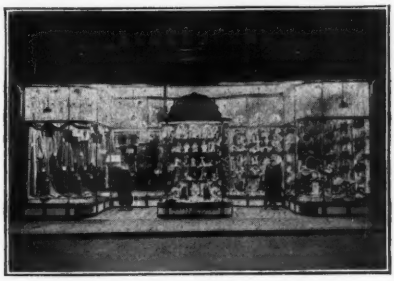


A Furniture Store lighted by Holophane Reflector Bowls.

In a Motor Car Showroom we need an imposing style of lighting. By using Holophane spheres the light is diffused and the shadows are softened. The light penetrates under the cars and is distributed all over the room. Every detail can be clearly seen.

A Motor Car Showroom lighted by Holophane Spheres.

In this show-window Holophane "F" type reflectors are used concentrating the lights on the goods. This photo is selected as showing the good effect of such a series of reflectors round the top of the window. Note that by merely introducing a silk screen in front of these units the method (designed in times of peace) can be made to comply with the present official regulations.



Typical Holophane Window Lighting. Lighted by "F" reflectors.

SOME TYPICAL HOLOPHANE SHOP-LIGHTING INSTALLATIONS.

SCIENTIFIC ILLUMINATION: ITS AID TO BUSINESS.

Under the above title a booklet with similar aims has been issued by the General Electric Co., Ltd. The introduction is an attractively-written summary of good window lighting. "Let us carry our minds back," says the writer, "to the days of yore when shops were dingy, windows were small, accommodation was limited, travelling was a hardship, and above all when lighting was a matter of oil lanterns and gas flares which vied with one another in their feeble efforts for supremacy! Then compare this picture with the conditions existing with to-day. Whereas in the days gone by, shopping was looked upon by the majority as a necessary evil, the average woman and child of to-day—and even the average man—finds pleasure in a jaunt round the bright and attractive shops."

Attention is drawn to the scenes of such shops as Harrod's and Peter Robinson's, which have made a feature of their shop-window lighting.

The three golden rules to be observed by modern traders are summarised as follows:—

First, make your window bright and attractive, display your goods to the best advantage, and under the most favourable conditions. Let your windows speak for you—let them say, "Come inside, we have more to show you."

Secondly, see that the public, once inside, are comfortably accommodated in bright and pleasant surroundings, and take care that the light is sufficiently good and so arranged that they are enabled properly to inspect your wares.

Thirdly, cultivate that appearance of success for both the inside and outside of your establishment. This again can only be made possible by strict attention to all details, prominent amongst which again figures the question of correct illumination.

The issue of this booklet shows the influence of the work that the Illuminating Engineering Society has been carrying on for the last five years, and it may be added that many of the best photographs reproduced therein originally appeared in the ILLUMINATING ENGINEER.

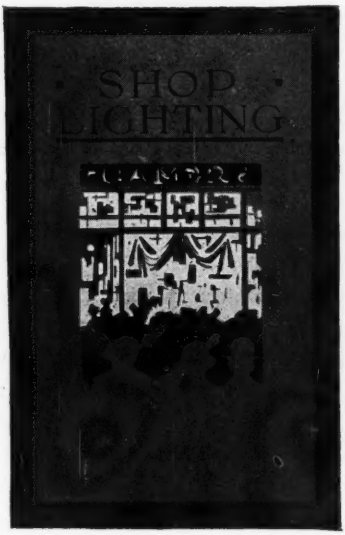
This is the corner window at Harrods Stores. The window is completely lighted by Osram lamps in metal reflectors, concealed at the top of the window. The installation was first described in THE ILLUMINATING ENGINEER (November, 1912).

View of Messrs. Harrods, Ltd. (Brompton Road, London), where the G.E.C. "Dalite" system is employed.

B.T.H. SHOP LIGHTING.

The arrangement of the British Thomson-Houston's pamphlet is characteristically novel. There is a brief introduction summarising the requirements of good lighting, namely: (1) Plenty of light; (2) even distribution; (3) good diffusion; (4) freedom from glare; (5) a light of suitable colour; (6) an artistic and attractively arranged equipment; and (7) efficiency. Following this we have notes on a great variety of shops (drapers, chemists, furniture dealers, confectioners, outfitters, motor-car showrooms, &c.) accompanied by photographs, taken by artificial light. We have selected one or two particularly interesting installations, such as the photograph of a tobacconist's shop showing the conditions of lighting before and after the arrangements had been changed. The contrast between the conditions of illumination produced by the unscreened bare lamps and the concealed units is very marked, and there can be no comparison between the ease with which the goods can be seen in the respective cases and the effectiveness of the two installations.

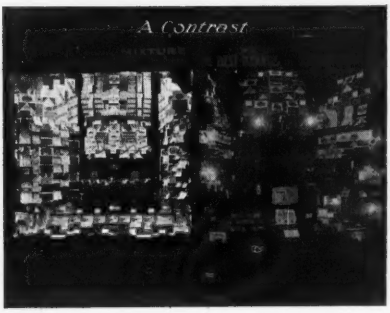
The latter part of the booklet contains an analysis of the chief methods of shop lighting ("direct," "indirect," "display," &c.), and the concluding pages are devoted to matter descriptive of British Thomson-Houston lighting units.



Cover of the B.T.H. Booklet on Shop Lighting.

"Concealed Lighting" with Mazda Lamps and Mazdalux Reflectors. The top curtain is moved to show arrangement of reflectors to get even lighting.

Mazda Lamps in B.T.H. "Eye-rest" Indirect Fittings in Tea Room.



An Interesting Comparison.

One half of window lighted on concealed principle with Mazda lamps; the other half shows bare lamps in line of vision.

AN INTERESTING SHOW-WINDOW EXHIBITION.

THE GAS LIGHT AND COKE COMPANY'S SHOWROOM IN THE EDGWARE ROAD.

THE two illustrations on the opposite page are reproduced from photographs, recently taken entirely by artificial light, of the showroom of the Gas, Light and Coke Co. in the Edgware Road. The installation was described by Mr. Goodenough at the last meeting of the Illuminating Engineering Society.

The window is particularly interesting at the present moment as being arranged specially to comply with the official regulations, and yet it will be agreed that the effect is, from an illuminating engineering aspect, distinctly good. This only illustrates the correctness of the view that a window lighted on the concealed method has an excellent chance of "passing the censor."

The upper photograph was taken from outside on the pavement, the camera being brought exceptionally close to the window so as to give the effect of a person looking in. However, people naturally can approach somewhat nearer than a camera can do and therefore see rather more than is visible in the picture. It will be observed that there is a dark blue border round the base of the window. Behind this are placed a row of six burners, equipped with reflectors so as to serve as "footlights." This arrangement is clearly seen in the lower illustration which was taken from inside the shop.

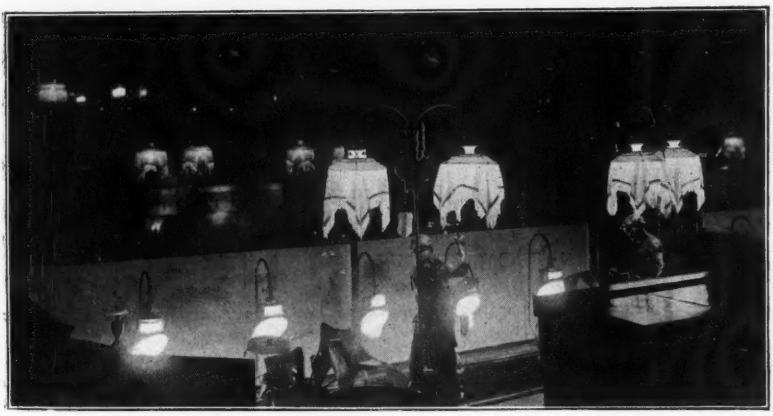
Another window devoted to cooking apparatus is lighted in a similar way. From the street the effect is quite stage-like, all the metal work showing up to good advantage owing to the absence of bright lights anywhere in the window. It should be mentioned that the burners in the conical shades overhead are not lighted in the ordinary course as a little of the light from them would pass over the blue border and illuminate the pavement.

THE BRITISH COMMERCIAL GAS ASSOCIATION.

THE annual meeting of the British Commercial Gas Association was held on Tuesday, October 27th, when Mr. F. W. Goodenough, the chairman of the executive committee, presented the report. It was stated that the sales of pamphlets, booklets, and posters from the commencement of the Association's work now totals over 4½ million copies. Of particular interest was Mr. Goodenough's statement that the Association would by no means restrict its activities on account of the war. It was also stated that the Association was sending a supply of playing cards bearing their advertisements to the military hospitals in this country, and a supply of matches bearing small advertisements to the troops at the front.

Lumina Bureau Photo.

View looking into the window from the pavement. The light is supplied by concealed burners placed behind the screen seen at the base of the window.

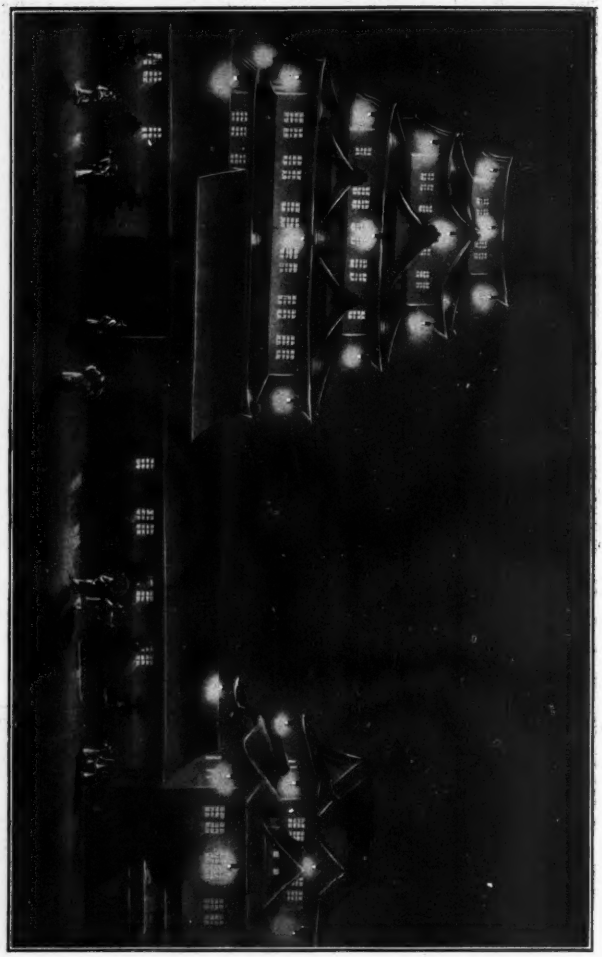


Lumina Bureau Photo.

View taken from inside the room, showing the arrangement of the concealed burners equipped with reflectors.

Two views of the Show Room of the Gas Light and Coke Co. in the Edgware Road (London, W.).

(Taken entirely by artificial light.)



Here is another interesting example of the introduction of western methods of illumination in the East. The building is a temple placed at the entrance to the Industrial Exhibition at Nagoya, Japan, a few years ago. The exterior was lighted by 64 "Blanlite" outside lamps, and 500 Bland burners were used in the interior.

A CORRECTION.

"Tubolite" Lamps.

Manufactured in England by the Linolite Company (25, Victoria Street, London, S.W.).

WE regret that through a clerical error in our last issue (page 529) it was made to appear that the "Tubolite" lamps are manufactured at the Osram Lamp Works. ("Tubular" was the word intended.)

We understand that the "Tubolite" (Registered Trade Mark) lamps are *entirely made in this country* by the **Linolite Company,** which has no connection (and has never had any connection) with the Osram Lamp Works.

The Linolite Company employs only British capital and British labour in the manufacture of "Tubolite" lamps and fittings.

A VISIT TO SOME OF THE LEADING INCANDESCENT MANTLE WORKS ROUND LONDON.

In our last issue we gave an account of some visits to various factories making electric incandescent lamps. In this number we are now giving a similar account of our visits to two of the leading manufacturers of incandescent mantles, Messrs. Curtis's and Harvey's works at Dartford, and the factory of Messrs. Falk, Stadelmann & Co. at Earlsfield. The account of another visit undertaken to the factories of the Plaisetty Manufacturing Co. is unavoidably held over to our next number and we have made application to various other companies for permission to visit their works.

In the incandescent mantle business the stoppage of Continental supplies naturally caused some inconvenience, but the factories are now working at high pressure to meet the demand.

It is difficult to state with any precision the number of mantles used in the British Isles per annum, but from inquiries we have made, we understand that the quantity exceeds one hundred million; of which, in normal times perhaps little more than a quarter would be manufactured in this country. Factories in Britain are therefore in a position to do a vast amount of business. In fact they "have greatness thrust upon them" (or will do if the war continues for any length of time, as extensions will probably become necessary).

In every case we were informed that the demand for mantles was quite unprecedented. But, as is well-known, there has been some question as to how far the industry may be affected by a stoppage of importation of necessary materials, particularly thoria and other chemicals. As was recently stated in these columns a store of thorium nitrate was accumulated through the foresight of the South Metropolitan Gas Co., and it is understood that there are other sources. So far manufacture has not been very greatly checked although presumably most makers would prefer to feel that unlimited supplies were available.

The question is admittedly an important one to the gas industry and we hope to be able to say something further on the subject on another occasion.

CURTIS'S AND HARVEY'S INCANDESCENT MANTLE WORKS.

These works, together with the gun-cotton factory of the same firm, are situated at Dartford. We were taken round by Mr. W. Edwards, the chief chemist, one day last month, and found the experience most interesting.

In the course of the visit some questions were put relative to the effect of the war. The immediate influence has been to give the factory an exceptional amount of work, and it was evidently going under pressure during our call. It may be said that the mantles are entirely British-made. We were shown a variety of types of stockings (single knitted, triplex, quadruplex, &c.) being knitted from the Ramie thread, and it was stated that artificial silk is now being used very considerably for high pressure work. We were given to understand that there is no difficulty in getting a sufficiency of these materials. The only trouble (which all makers are experiencing to some extent), is the question of maintaining the supply of thorium nitrate; but it is hoped that this difficulty will be quite successfully met. Certainly, in view of the great opportunity before British makers at the present moment, it is desirable that these much-needed materials should be made in the requisite quantity in this country.

The knitted material is washed in acid to remove any traces of deleterious impurities (iron must be particularly guarded against), and the acid is subsequently removed by washing in tanks of distilled water (of which the firm manufacture their own supply): The yarn is then thoroughly dried in cupboards at a temperature of 100° F. While passing through this part of the works we had a glimpse of the chemical

laboratories where the mixing is done—naturally a very important process.

The impregnation of the mantle appears to the onlooker a simple matter, the fabric being merely dipped in the solution and then run through a rolling machine which is adjusted so as to squeeze out all but a standard amount of solution. Subsequently each fabric is mounted on an appropriately shaped mould and transferred once more to the drying cupboard. A small fringe of hardening solution is also applied to the neck of the mantle.

The processes of preparing the mantles from the stockings are exceedingly interesting. The cutting into lengths is done with dexterous rapidity, and the attachment of the porcelain rings to the inverted mantles strikes one as a particularly neat operation. A somewhat special process is used by the firm for some inverted mantles. The ends are so prepared as to avoid the bulky knot of material which occurs in the ordinary method. The material being of the same thickness throughout, there is no loss of luminosity at the tip of the mantle. It was interesting to hear that the numbers of upright and inverted mantles sent out are now approximately equal; before long, no doubt, the inverted will predominate.

In the case of the upright mantles the heads are ordinarily drawn up tight with asbestos thread and finished on a machine in such a way as to give the requisite loop for suspension.

But in the "Ironclad" mantle manufactured by Messrs. Curtis's and Harvey the heads are capped with metal. The cap consists essentially of two plates between which the fabric is placed, and the machine descends and clamps the two plates together.

In the next department we see upright and inverted mantles being burned off and "formed" by means of burners receiving gas at a pressure of about 250 inches water. In the forming process the mantles are thus subjected to a pressure far in excess of anything they will experience in practice, even if they were intended for high pressure lamps. The process can be done by hand, but there are also machines at work by means of which a considerable number can be treated simultaneously. The mantles are gradually raised and lowered over the flames until completely treated in every portion, and are then removed to the collodionising room.

The machines here are perhaps the most interesting in the factory. The racks of mantles are mounted on an endless chain. At one point a tank containing the collodionising solution comes up and meets them and covers the mantles for a moment. (It may be noted that the solution is brought up to the mantle and not the mantle to the solution.) After immersion the mantles rise and are passed on by the chain into a drying chamber, while a new set takes their place. Eventually the chain emerges from the drying chamber carrying the mantles, now perfectly dry. As they are removed they are cut to a size by a series of revolving knife-edges, and are finally checked with a gauge to ensure that they fit the burners for which they are intended. Selected mantles are also subjected to tests of illuminating value in the photometer room and to treatment with a "shocking machine" in order to try their strength and durability.

The last stage is the packing. It is worth noting that the support of the Ironclad mantles is different from that of the ordinary variety using an asbestos loop; with the Ironclad type a metal supporting hook is inserted, but the ordinary type is merely packed in with cotton wool in the usual way.

HOW "VERITAS" MANTLES ARE MADE.

A VISIT TO THE WORKS OF MESSRS. FALK, STADELMANN & CO. AT EARLSFIELD.

BY the courtesy of Messrs. Falk, Stadelmann & Co., Ltd., we recently visited the works at Earlsfield where the Veritas and other mantles produced by this firm are made. The factory was in full swing at the time of our visit. Owing to the stoppage of Continental mantle supplies, it is difficult to meet the demand that has sprung up for the British-made variety. We understand that at the present time the output from these works does not fall far short of 70,000 a day.

We were shown several varieties of knitted Ramie yarn, which forms the body of the mantle; all, however, are treated in the same way. The first step is the cutting of the fabric into stockings of appropriate length. Close at hand the girl operators are at work strengthening the head of the stocking by an envelope of tulle. Next we see the stocking immersed in the blue impregnating solution of nitrate of thorium and other materials. (It should be mentioned that the colour is immaterial and merely serves as an indication that the stocking has been impregnated.)

Sewing.

Dipping.

Burning off.

Three stages in the Manufacture of "Veritas" Mantles at Earlsfield.

The concentration of solution used and the time of immersion vary somewhat according to the type of mantle made, but after a suitable time the material is passed rapidly through rollers; these squeeze out all but a certain predetermined amount of solution which remains in the material.

The damp stockings are then stretched on to a series of models having approximately the shape of the finished (unburned) mantle. They are then placed on racks in steam-heated ovens to be dried. It is also usual to add a little of a second impregnating material round the neck of the stocking. This has nothing to do with the incandescence, but serves to strengthen the head of the mantle; this solution also is coloured so as to serve as an identification.

In the subsequent operations we find the mantle assuming its proper shape. If of the upright type we see the head sewn with asbestos thread, which is subsequently drawn together leaving the usual loop by which the mantle is suspended; if it is inverted one end has to be stitched together and the other to be attached to the little fireclay ring —a highly fascinating and dexterous operation.

We now have the mantles approximately as they appear in daily life, but somewhat larger. They are next mounted on racks and the fabric is ignited, burning away the Ramie fibre completely and leaving only the skeleton of active incandescent material. During this process the mantle shrinks considerably and becomes very brittle. It must therefore be handled with care. The series of burned-off mantles is now transferred to a machine where, for a space of time fixed by a sand-glass, they are treated with a Bunsen gas flame at high pressure. This flame is alternately brought into the mantle and withdrawn until eventually it is "blown out" into a symmetrical proper shape and hardened. Even so the mantle, though much stronger than before, is by no means suitable for transit. It must first be immersed in a solution of collodion and then goes into the drying oven once more. In all these processes, for the welfare of the employees care has to be taken that the ventilation is good. The difference in the method of providing ventilation for the incineration processes for the upright and inverted mantles was distinctly interesting. In the former case the heated gases escape upwards and are drawn away by a ventilation shaft in the ordinary way. But in the case of the inverted mantle the hot gases go *downward* and must therefore be sucked away underneath.

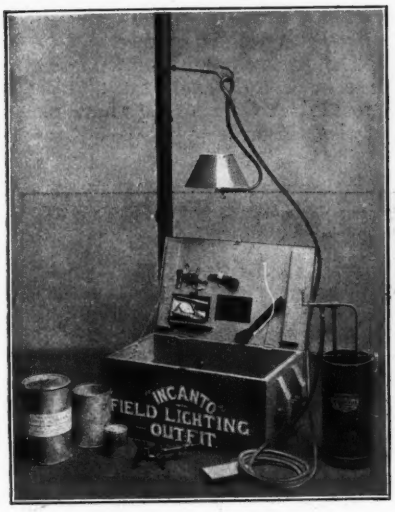
When the collodion-coated mantles are dry they are removed from the oven. The inverted mantle is then a finished article provided it passes the gauge of the burner for which it is intended. The upright mantle, however, is deftly trimmed with a knife, sufficient being removed from the base according to the size intended. (Needless to say all the cuttings are treasured and redissolved to form eventually more impregnating solution.) In addition to the gauge-test, a certain number out of each batch of mantles is withdrawn and subjected to tests for candle-power and shock-resisting capacity.

The final stage is the packing of the mantles in the usual cylindrical boxes, a piece of jugglery which shows off the dexterity acquired by the operators in this business. It was something of a revelation to the writer to find that even the boxes in which the mantles are packed are made on the premises—indeed, to many people this would be one of the most interesting things to be seen in the factory. One observes great squares of cardboard being sliced up to form boxes of all sizes, labels being printed to attach to them, a long row of wire-stitching machines for stitching the boxes for inverted mantles, and, in one corner of the room, a joiner's shop where the wooden packing cases are prepared.

But the machines engaged in the preparation of the cylindrical mantle-boxes are the most striking. One sees a line of machines punching away methodically at heated cardboard and the lids of the boxes accumulating underneath. Next door there is an endless sticky roll of cardboard receiving its appropriate labels and being wound into a cylinder while doing so; and then being cut to length, passing on through a drying chamber, and finally falling out complete and ready for the lids from next door. If, in the earlier processes, one admires the dexterity of the girl operators one is subsequently tempted to believe that mere juxtaposition to the box-making machinery might, in time, produce handiness of this description.

Such a visit leads one to appreciate how many are the processes which go to the making of the complete mantle, and it would doubtless be a useful education for many buyers of mantles to know a little more of their manufacture.

THE INCANTO FIELD AMBULANCE AND CAMP OUTFIT.



Lamp in position fed by Incanto generator outside tent.

The above two illustrations refer to a compact form of field outfit introduced by the Thorn and Hoddle Acetylene Co. Ltd. (151, Victoria Street, S.W.).

The outfit (No. 2) comprises :—

Plant.—1 Special No. 2 Pattern L Generator, carbide capacity, 2 lbs. 15 ft. $\frac{3}{8}$ in. by 3 ply canvas insertion tubing. 1 single light wrought iron pendant, fitted with hook. 1-60 c.p. burner. 1-10 in. enamelled iron reflector. 1 special cramp for attaching to ridge pole.

Cleaning Outfit.—1 wire burner cleaner. 1 pair of pliers. 1 tube of jointine. 1 tin (damp proof) containing matches.

Spare parts.—6-60 c.p. burners. 1 spare double burner cock for generator. 1 spare carbide container.

Carbide.—14 lbs. calcium carbide, packed in lever top tin.

The whole outfit is packed away in a wooden box 26 in. by 17 in. by 12¼ in.; the total weight is 66 lbs.

At the present moment when light is being used for all manner of purposes on the battlefield such outfits deserve attention. Besides being used for hospital tents, canteens, &c., at the Front they should prove quite acceptable at many of the camps for Kitchener's Armies, which are springing up mushroom-like, all over the country.

POPE "ELASTA" LAMPS.

WE are informed that the Tower Cinema Picture House, recently opened at Peckham, which is now the largest in London, is fitted throughout with Pope "Elasta" Wire Lamps, some 2,500 lamps being installed there.

TWO UP-TO-DATE HIGH-PRESSURE GAS INSTALLATIONS.

FOR the two photographs used with this article we are indebted to the courtesy of Messrs. J. Keith and Blackman Co., Ltd.

They show two distinct sets of lighting conditions. The first illustration refers to the lighting of a factory of Messrs. Weber Bros. & Phillips (Tottenham), which employs a combination of general and local lighting. There is a series of lamps placed amongst the girders which serve to light the whole shop, and there are also special lamps over each sewing machine equipped with suitable metal reflectors. On the sewing machine benches, the illumination on the needle-bar is equal to 35 foot-candles. This is secured by a 60 c.p. unit with a deep reflector fixed 1 ft. 3 ins. above the working surface. There is one unit to each machine, and the light is movable by means of a universal joint attached to the downstem.

The illumination on the cutting-out benches is equal to 9 foot-candles, and is provided by 300 c.p. lights placed 5 ft. above the working surface.

The arrangements for the punching machines and the amount of illumination provided are similar to those on the cutting benches.

FIG. 1.—Factory devoted to work with dark materials. Strong local lighting as well as general illumination.

At the present moment, when wholesale tailoring factories are all working at great pressure making uniforms for Lord Kitchener's new army, the lighting of such workshops is a most important matter. It is worthy of note that the standard of illumination required depends on the nature of the material. In this particular factory black material, which reflects very little light, is mainly used. Obviously, therefore, more light will be

needed than in a factory devoted exclusively to the making of white blouses.

The second illustration shows the engineering shop of Messrs. Masson, Scott & Co. (Fulham). In this case the illumination is provided mainly by a series of powerful lights down the centre of the shop.

The main bay, where the erection and fitting is done, is lighted from above the crane by 1,500 c.p. units at a height of 25 ft., and an average illumination of 1·6 foot-candles was measured on the floor.

Here again the photograph gives an excellent impression of the powerful well-diffused illumination provided, which is essential in engineering work of this class.

The **Trus-Con Laboratories** (Central House, Kingsway, London, W.C.) send us a booklet attractively printed on grey mat art paper, describing the use of "Trus-con" waterproofing paste, as used for various reservoirs and other large works.

FIG. 2.—General lighting in an engineering works.

On the right-hand side of this main bay, machines are closely packed; on the left are the fitter's benches, smithy, &c. On the fitter's bench there is an average of 8 foot-candles obtained from 300 c.p. units placed 4 ft. above the working surface.

Various other measurements were taken in this factory on certain lathes and milling machines, which showed results of not less than 3·5 foot-candles.

COX'S AIR GAS CO.

We are informed that Mr. Fred. J. Cox, M.I.Mech.E., has purchased the business and patents of the Machine Gas Co., Ltd., and will in future conduct it as **Cox's Air Gas Co.**

The address of the offices and works is:—180, Arlington Road, Camden Town, London, N.W., where all communications should be addressed.

TILLEY'S HIGH PRESSURE LIGHTING APPLIANCES.

We were recently given an opportunity of inspecting some of the appliances of the **Tilley High Pressure Gas Syndicate** (44, Kingsland Road, London, N.E.), and while doing so made a few inquiries as to the effect of the war on business. Experience is not discouraging, and although the firm has lost several useful employees who have gone to the front, business is proceeding much as usual. The stoppage of Continental supplies is not causing inconvenience except so far as is the general experience just now. The chief difficulty is the supply of heat-resisting glassware which was formerly made abroad but is now beginning to be manufactured in this country. The lamp itself has always been British made. The official regulations for diminishing the lighting of London have naturally had a restrictive effect but there is plenty being done in towns where no such regulations apply, and in connection with the lighting of factories.

We examined several typical high pressure lamps, stated to give 50 to 60 candles per cub. ft. of gas per hour. The chief reason for the efficiency of these lamps lies in the very careful mixing of the gas and air, which renders elaborate pre-heating arrangements unnecessary. Precautions are taken to avoid contamination of the ingress of primary air and there is an efficient "dust-trap." The various parts are solid and simple in construction and are released for cleaning purposes by a distinctly ingenious device. Another cunning contrivance used on some of the lamps is the patent nipple-cleaner. A thin wire, which is ordinarily kept away from the aperture so as not to obstruct the flow of gas, can be readily pushed into it by merely turning a small screw, thus forcing out any obstruction.

Among other objects of interest was a distance lighting device and several neat forms of lamps for factory use. These were equipped with the most up-to-date anti-vibration devices (using a ring of small copper tube in preference to the ordinary flexible tube arrangement), one such lamp equipped with a compact parabolic reflector seemed particularly appropriate for lighting lathes and small machine work. It is curious how often the workman still requires education in the use of such devices!

GLASS WORK SPECIALITIES.

ANOTHER VISIT TO THE WORKS OF MESSRS. J. & W. B. SMITH, 15-23, FARRINGDON ROAD, LONDON, E.C.

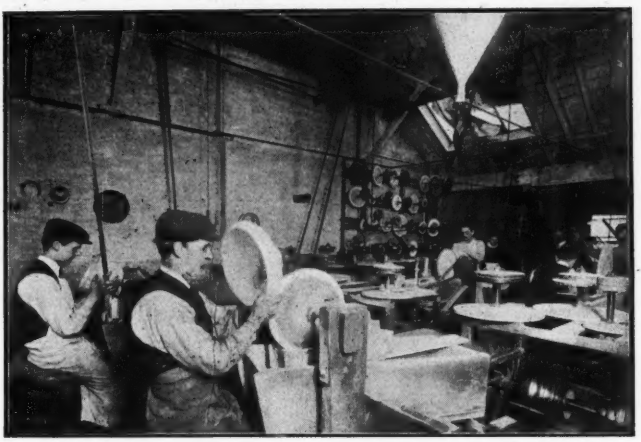
At the present moment much interest is being taken in glasswork of all kinds owing to the shortage of supplies from the Continent. During a recent visit we had an opportunity of seeing some of the etching, sandblasting, brilliant cutting, and finishing work of Messrs. J. & W. B. Smith, besides various operations on metal, carried out on the premises.

One feature is the making of advertisement signs. We saw a large specimen, mirrored at the back, depicting "Silva" lamps, "Glasmi" mantles, "Briton" Burners, &c., about to be sent off. It was satisfactory to learn that business in signs still holds up in spite of recent regulations affecting the lighting of London. In work of this kind hydrofluoric acid plays an important part; being sometimes merely used to obscure the glass, in others to etch in letters which may subsequently be coated with gold leaf, &c. It is also used to produce a "satin finish" on glass globes.

In another room glass-cutting operations were being carried out. The patterns are traced on glass by means of rotating stone wheels of various and sizes; several of the men engaged in this work have been with the firm for considerable time and are quite veterans in the art, whilst the foreman of this department has been with the firm over 50 years.

Yet another operation is the sandblasting of globes of every description, which is another method of securing a diffusing surface. The sand-blasting machine is of an up-to-date type and is so contrived that the whirling sand is under cover and the operator runs little risk of breathing it in. There are two distinct compartments one of which is used while the other is being made ready. It may be said that all these processes are not so simple as they appear to the onlooker, and that a considerable amount of practise and manual dexterity is needed to get good results.

In other parts of the premises there is an Electro-plating Room where all manner of metal things come to be renovated, and are turned out "as good as new." A special department is devoted to the renovation of old gas and

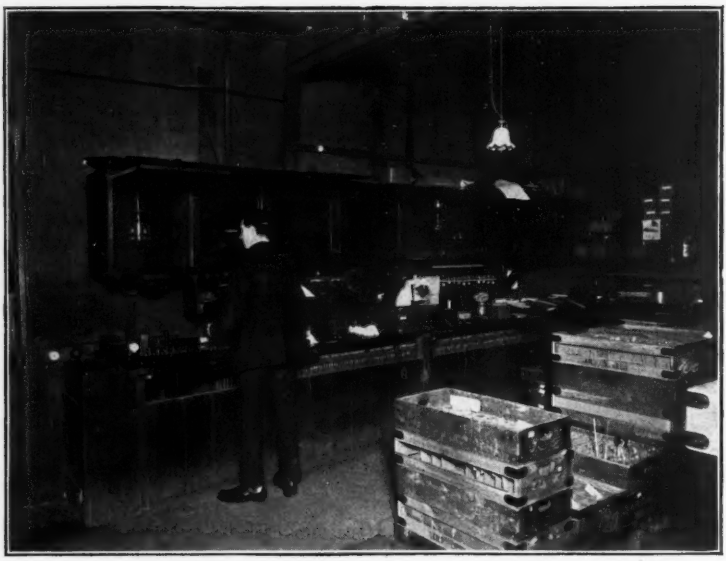


Cutting fine glass patterns on glass bowl.

The sand blasting machine. It is divided into duplicate compartments and is so arranged that none of the whirling sand escapes to trouble the operator.

Two operations in glass working at the factory of Messrs. J. & W. B. Smith, Ltd.

electric fittings. The process is quite a lengthy one in some cases. The encrusted grime has to be washed off, the pits in the metal ground away and finally a high polish added. Most of this work is done with rotating wheels using various grinding and polishing materials, and a variety of these is used. Altogether one received an impression that the process of cleaning up of old fittings is a distinctly strenuous one ; but it is a branch of work which should appeal to many consumers who are anxious to economise in these hard times.



A view of part of one of the photometric laboratories at the works of the **Edison & Swan United Electric Light Co.** (Ponder's End, London, N.)

A lamp mounted in the rotating lamp holder is being compared with one of the large bulb standards. The eye-piece of the Lummer-Brodhun photometer projects through the screened box in which it is mounted, and the electric controlling apparatus and instruments are mounted immediately under the photometric bench.

VARIOUS ITEMS.

The GENERAL ELECTRIC CO., LTD., send us an ash-tray made of **Equiluxo glass**—an ingenious advertisement of this form of glass that is being widely used in the form of bowls and spheres for store-lighting, especially with half-watt lamps.

We are also asked to state that the GENERAL ELECTRIC CO., LTD., has again secured a G.P.O. six months' contract for the supply of Osram lamps.

WM. GEIPEL & CO. (Vulcan Works, St. Thomas Street, London), particulars of **Time Switches.** List No. 136 for 1915 embodies nine additional switches, varying from 1½—250 ampères and including a time switch for staircase and corridor lighting.

Lektrik Lighting Connections by Wm. Perren Maycock is a handy little booklet summarising the value of ample provisions for the control of lights, and, as its name implies, fully illustrated by diagrams of the various "Lektrik" special devices. Reference is made to the Examinations for Wiremen organised by A. P. Lundberg & Sons.

VERITYS LTD. (31, King Street, Covent Garden, W.C.) send us particulars of Luminous Radiators and **Aston Lanterns** for half-watt lamps.

An attractive little booklet contains an imposing list of well-known mansions, public buildings, theatres, &c., that have installed the firm's lighting fittings.

We also note with interest that the firm has arranged at their showrooms **a demonstration** of the advantages of direct, indirect and semi-indirect fittings.

INDEX, December, 1914.

PAGE

Drawing Room, Chandelier Lighting of 553
Editorial .. .. L. GASTER .. 543
Glasses to Absorb Injurious Radiations 552
Illuminating Engineering, Short Notes on 558
" " Summary of Progress during the last year—*continued* 547
Illuminating Engineering Society (U.S.A.), Eighth Annual Convention 555
Law Courts, Illumination in the .. .. A. S. OSBORN .. 554
Review of the Technical Press 580
Topical and Industrial Section 563

Shop Lighting in Time of War 561
Holophane Glassware for Shop Lighting 562
"Scientific Illumination: Its Aid to Business" (G.E.C.) 564
B.T.H. Shop Lighting 565
The Gas Light & Coke Co.'s Showroom (Edgware Road) 566
British Commercial Gas Association, Annual Meeting 566
Visits to Incandescent Mantle Factories near London 569
Curtis's & Harvey's 569
Falk, Stadelmann & Co. 570
Acetylene Camp and Ambulance Lighting Outfit (Thorn & Hoddle) 573
Two Up-to-date High Pressure Gas Installations (J. Keith & Blackman, Ltd.) 574
Tilley's High Pressure Lighting Appliances 576
Some Processes Employed in Glassworking 576
Ediswan Photometric Laboratory 578

ACCESS OF DAYLIGHT IN THE COUNTRY COTTAGE.

A short time ago the Illuminating Engineering Society was occupying itself with the natural lighting of schools. Some regulations governing the amount of window space per square foot of floor area were mentioned.

These rules are not entirely satisfactory but they do at least furnish a rough standard of access of daylight. A visit to the country often makes one wonder how the people in some of these remote cottages, with their tiny windows, manage to exist.

The snapshot facing this note is a case in point. A glance is enough to show that the minute windows, occupied by diamond glass more or less obscured, are quite insufficient. Yet this defect occurred in cottages of solid construction and on an estate which seemed to be, in other respects, a model of sanitation, besides being delightfully picturesque.

REVIEW OF THE TECHNICAL PRESS.

MANY of the American papers deal with the half-watt or "gas-filled" lamps. Luckiesh (*Elec. World*, Sept. 19th, Nov. 14th) describes **the lighting of colour-printing works** with half-watt lamps in special tinted globes giving a close resemblance to daylight; he shows how these lamps can be readily applied to photography. Dr. Sharp, in a recent paper before the Illuminating Engineering Society in the United States, has discussed certain difficulties in the **photometry of half-watt lamps.**

There have been a considerable number of articles dealing with **photometry.** Several recent contributions analyse the sources of error in the **Pentane lamp** very exhaustively; in fact much valuable work on this standard has recently been done in the United States. It is shown that 15 to 30 minutes must be allowed for a steady state of things as regards temperature, &c., to come about, that the English lamps are somewhat more reproduceable than those made in the States, but that in any case differences of the order of 1 or even 2 per cent. are apt to occur between the candle-powers of individual lamps. A. G. Jones refers to the **photometry of headlights.** A useful figure is the "multiplying factor," *i.e.*, the ratio between the candle-power of the lamp in reflector, to the candle-power of the lamp alone in the same direction.

In the British papers frequent reference is made to the effect of the "lights out" order on existing contracts for shop outside lighting and street lighting. Meantime other towns besides London (*e.g.*, Birmingham) are also adopting precautionary changes in lighting, and in Scarborough "somewhat drastic" steps have been taken.

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Also an account of visits to some of the leading Incandescent Mantle Factories near London.

Other matters dealt with include :—

LIGHTING OF A DRAWING ROOM—SHOP LIGHTING IN WAR TIME—THE USE OF LIGHT IN THE INSPECTION OF LEGAL DOCUMENTS, &C.

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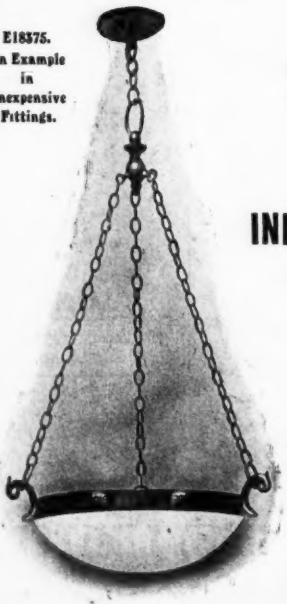

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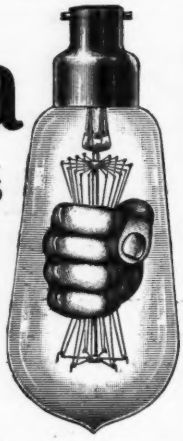

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See also page iii.

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